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KALAMAZOO RIVER ANGLER SURVEY AND BIOLOGICAL TESTING STUDY FINAL REPORT

SUBMITTED BY

ENVIRONMENTAL EPIDEMIOLOGY DIVISION
COMMUNITY PUBLIC HEALTH AGENCY
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Abstract

The Kalamazoo River Angler Survey and Biological Testing Study was undertaken to evaluate PCB, DDE and mercury exposure in sport anglers who fish the affected portions of the Kalamazoo River and Portage Creek (KR/PC). The primary public health concern examined in this study was whether exposure to PCB, DDE and mercury through consumption of contaminated fish significantly influenced the levels of these environmental contaminants in blood, and whether concomitant changes in health conditions would be reported by the participants.

This study was performed in two phases. PHASE I identified persons fishing within the affected zone and obtained their demographic information, fishing behavior and fish consumption patterns through a questionnaire survey. Consenting PHASE I participants were then enrolled in the PHASE II follow-up study which recorded their self-reported health conditions, occupational histories, tobacco use, alcohol consumption, and blood specimen chemical residue analyses.

Some differences were found between descriptive characteristics of anglers from Allegan and Kalamazoo Counties. Allegan County anglers were more likely to be younger, have a lower educational level, and fish as a source of food, but they were less aware of the fish consumption advisories. The average level of unemployment among anglers in both counties was higher than the statewide rate. About 75% of all the anglers surveyed reported eating fish from the Kalamazoo River no more often than one meal per week.

The angler survey identified approximately 455 anglers who expressed interest in participating in the PHASE II Health Survey and Biological Testing Study. Of the 155 participants, Kalamazoo River fish-eaters were observed to have significantly higher residue levels of total PCB and DDE than non-fisheaters. When the effects of potential confounders such as age were accounted for the observed significant association between PCB/DDE levels and fish consumption was no longer statistically significant. However, it is a public health concern that consuming contaminated fish has the potential to contribute significantly to the body burdens of PCB and DDE. Analysis restricted to anglers with detectable mercury levels showed that fish consumption did not influence the level of mercury in the blood. No associations were observed between contaminant levels in blood and self-reported medical problems. It is recommended that risk management decisions include continued testing of river fish for contaminant levels. Risk managers must ensure that contaminants in the affected zone of the Kalamazoo River and river sediments are at levels of no public health concern.

Less than half of the surveyed anglers indicated an awareness of the fish consumption advisories in effect for the Kalamazoo River. This study also found that smoking was twice as prevalent among anglers than the general public in Michigan. It is recommended that the State Department of Community Health and the county health departments develop more effective means of communicating and ensuring compliance of the fish consumption advisory. It is recommended that

smoking cessation programs be made available specifically to anglers by state and local health departments.

PHASE I
Kalamazoo River Angler Survey

Introduction

During a study in 1971, the Michigan Department of Natural Resources (MDNR) identified polychlorinated biphenyls (PCB) contamination in the water, sediments, and fish from the Kalamazoo River and Portage Creek (1). The Michigan Department of Public Health (MDPH)[1] issued a fish consumption advisory for portions of the river and creek in 1977 and the advisory, although modified over the years, remains in effect. The MDNR/Michigan Department of Environmental Quality (MDEQ)[2], the U.S. Environmental Protection Agency (EPA), and the International Joint Commission(IJC) have cited various portions of the river and creek as areas of concern and investigation.

On August 30, 1990, the EPA listed the Allied Paper/Portage Creek/Kalamazoo River Site (CERCLIS No. MID006007306) (AP/PC/KR), including Portage Creek below Cork Street, the Kalamazoo River from Portage Creek to Lake Allegan, and selected paper waste disposal areas along the creek and river, on the National Priorities List (the Superfund list). As part of the Superfund process, the MDPH issued a Preliminary Public Health Assessment (PPHA) for AP/PC/KR in 1991 under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). The PPHA concluded that human exposure to PCBs was likely still occurring through consumption of contaminated fish from the affected zone of the Kalamazoo River and Portage Creek. The ATSDR Health Activities Recommendations Panel (HARP) recommended that the number of people eating fish from the Kalamazoo River and Portage Creek be more clearly defined (2). Based upon that determination, this exposure study involving biological testing was undertaken.

Background

Contamination with polychlorinated biphenyls (PCBs) has been found in the water, sediments, and fauna of the Kalamazoo River and Portage Creek and vicinity since sampling began in 1971 (Tables 1-4). The source of PCB contamination has been primarily linked by MDEQ/MDPH to the de-inking process associated with the paper recycling industry during a time when PCBs had been used in specialty inks or in carbonless reproduction paper. These uses were eliminated in the mid-1970s. The highest PCB concentration detected in sediments was in Bryant Mill Ponds at 1,000 parts per million (Table 2). The Allied Paper, Inc. Residual Disposal Area and the most

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[1] On April 1, 1996, the Michigan Department of Public Health (MDPH) Division of Health Risk Assessment (DHRA) was absorbed into the newly-formed Michigan Department of Community Health (MDCH). The site history and background section of this document uses the departmental identifiers in effect at the time of the events.

[2] On October 1, 1995, the environmental evaluation, regulatory, and enforcement functions of the Michigan Department of Natural Resources (MDNR) were transferred to the newly-formed Michigan Department of Environmental Quality (MDEQ)

highly contaminated sediment beds of Portage Creek have been fenced to prevent potential direct contact threats, incidental ingestion, and inhalation of contaminated surface particulates. However, the fencing does not mitigate the potential for consumption of contaminated fish in areas downstream.

In 1984, the MDNR listed the Portage Creek/Kalamazoo River site, from Kalamazoo to Saugatuck, on the Priority List for Evaluation and Interim Response under the Michigan Environmental Response Act (Public Act 451, Part 201). On August 30, 1990, the U.S. EPA listed the Allied Paper/Portage Creek/Kalamazoo River Site (CERCLIS No. MID006007306) (AP/PC/KR), including Portage Creek below Cork Street, the Kalamazoo River from Portage Creek to Lake Allegan, and several paper waste disposal areas along the creek and river, on the National Priorities List (NPL, the Superfund list). The Kalamazoo River is a tributary of Lake Michigan and has been identified as one of several significant sources of PCB inputs to the lake. Accordingly, the IJC has designated the river as a Great Lakes Area of Concern (7).

The 35 miles of the Kalamazoo River and 3 miles of Portage Creek which are within the defined boundaries of the Superfund site are also within the zone of the watershed with the most restrictive fish consumption advice. Contamination levels of fish in Lake Allegan, which is an impoundment on the Kalamazoo River immediately downstream of the Superfund site boundary in Allegan County, are comparable to those within the site boundaries. The advisory for Lake Allegan is also the same. Dams on all other impoundment areas upstream of Lake Allegan, but within the Superfund site description, have been removed and much of the contaminated sediment load has been translocated into the sediments of Lake Allegan. The total mass of PCBs in the river sediments, including Lake Allegan, has been estimated by MDNR/MDEQ at 230,000 pounds (7).

The MDPH first issued a fish consumption advisory for the affected zone of the Kalamazoo River in 1977. The advisory recommended that no species of fish be eaten from the river downstream of the city of Kalamazoo, nor from Portage Creek downstream of Milham Park. Maximum levels of PCBs originally detected in carp in the affected zone were as high as 164.5 parts per million (Table 3). Due to declining concentrations of PCBs over time, the advisory was modified in 1983 to include only carp, catfish, bass and suckers in the "DO NOT EAT" category (8). All other species remained in a "LIMIT CONSUMPTION" group (one meal per week for the general population; no consumption for nursing mothers, pregnant women, women who intend to have children, and children age 15 or under). The advisory for the 35 mile zone of the Kalamazoo River and the 3 miles of Portage Creek designated as part of the NPL site currently remains the same as in 1983. In 1990, consumption advice for the portion of the river downstream of Allegan Dam to Lake Michigan was relaxed to include fewer species due to improving conditions (9).

Despite continued existence of fish consumption advisories, local health officials and other local government representatives reported observing frequent fishing activity within the contaminated zone of the river during the early 1990s (10, 11). With the improvement of water quality over time, a diverse fish population exists in areas of the Kalamazoo River which were largely devoid of fish 25 years ago. Inadequate dissolved oxygen levels resulting from a heavy organic pollution

loading was one of the primary factors contributing to the earlier lack of fish life.

The U.S. Food and Drug Administration (FDA) tolerance level of 2 parts per million (ppm) in sport-caught fish is the guideline used for advising anglers regarding the potential human health impacts of eating fish from the contaminated zone. This tolerance level was adopted by FDA based upon risk assessments, economic considerations, and on the judgment of public health officials as being protective of human health. In Michigan, the level is applied for advisories in a manner to provide extra caution for women of child-bearing age, the unborn fetus, and young children.

Prior to the angler survey reported herein, no scientific survey had been conducted to document either the number nor the specific fish consumption habits of anglers in the contaminated zone of the Kalamazoo River and Portage Creek. Although PCB residues in the fish have been decreasing, potential public health impacts remain a concern.

Goals

The overall objective of this two-phase study was to determine if exposure to contaminants in Kalamazoo River fish was occurring at levels of public health concern. The goal of PHASE I was to determine the utilization of the affected portions of Portage Creek and the Kalamazoo River by sport anglers or other persons who regularly eat fish from these waters. The goal for PHASE II of the study was to look for associations between consumption of fish from the affected zone of the Kalamazoo River and body burdens of environmental contaminants and/or health complaints.

Specific Objectives

1) Identify and characterize the angler population utilizing the affected portions of the Portage Creek and Kalamazoo River.

2) Determine the primary reasons for the use of this resource.

3) Determine fish-consumption patterns of all anglers identified and assess their level of awareness of sportfish consumption advisories applying to the river.

4) Identify all persons who may be consuming significant quantities of fish from the river (e.g. those who received fish as gifts from anglers and/or those who otherwise obtained fish from fishing on their own, buying fish from anglers, or picking up discarded fish).

5) Determine willingness of persons (angler fish-eaters) identified above to participate in follow-up health studies and obtain addresses and telephone numbers of those who are willing to participate.

6) Develop a list of area anglers and nonanglers who are fish consumers for participation in PHASE II activities.

Methods

Survey Teams

MDCH made contractual agreements with the Allegan and Kalamazoo County public health agencies to conduct the field portions of the survey. Each county fielded a two-person team consisting of a female and male interviewer. With personnel safety considerations in mind, surveying took place only during daylight hours. Additionally, members of the team always maintained visual contact with each other in the field.

Pre-survey tours of the stream were made in both counties to identify locations where fishing was most frequently occurring and document the most popular hours/days of the week when fishing activity was highest. This information was taken into consideration in scheduling of survey team efforts during the most popular hours/days of the week. Field surveys were initiated in May 1994 and completed September 30, 1994.

Angler Survey Questionnaire Administration

An 18-item angler survey questionnaire was jointly developed by staff from ATSDR, MDPH and environmental health staffs from Allegan and Kalamazoo Counties (Appendix B). The survey teams approached anglers and asked them if they would be willing to participate in the survey designed to determine, the reasons for, and fishing patterns of individuals fishing in the areas of concern. Following a verbal consent of individuals who were observed fishing, members of the survey team administered an 18-item angler questionnaire. All questions were read to the anglers and the answers recorded on the questionnaire form. During the angler survey, individuals were asked if they would be willing to be re-interviewed as part of the quality control on the survey. If they agreed, their telephone number and address were recorded for follow-up interviewing. Participating individuals were also asked if they would consent to participate in the biotesting portion of the study.

Statistical Data Analysis

SPSS Version 6.1.3 for Windows (SPSS Inc., Chicago, IL) was used for analysis of the data. Univariate analysis was performed to provide a summary of descriptive statistics for each county. Descriptive statistics used to characterize continuous variables included means and standard deviations. Frequencies were used to characterize categorical variables. Chi-square test was employed to evaluate relationships between categorical variables. A two-sample t-test was applied to assess the association between continuous variables.

Results

The following section reports the results of the PHASE I survey, with particular reference to each of the aforementioned objectives.

Objective 1: Identify and characterize the angling population using the creek and river.

During May 5, 1994, through September 30, 1994, staff from the environmental health programs of the Kalamazoo County Human Services Department and the Allegan County Health Department encountered 1,090 anglers observed fishing along the Kalamazoo River within Kalamazoo and Allegan Counties, and conducted face-to-face interviews with 938 of these individuals yielding an overall participation rate of 86.6%. A total of 241 out of 246 anglers encountered in Kalamazoo County agreed to be interviewed (97.9% participation rate). In Allegan County, 697 out of 854 anglers who were approached by the survey team agreed to be surveyed (81.6% participation rate).

In Kalamazoo County, the survey team identified two "primary" fishing spots along the Kalamazoo River. These primary spots were Verburg Park in the City of Kalamazoo and Merrill Park in Comstock Township. Over 50 percent of the Kalamazoo River anglers interviewed in Kalamazoo County were found fishing at these two locations. No one was observed fishing at any time during the survey in the contaminated zone of Portage Creek from the Bryant Mill Pond to the creek's confluence with the Kalamazoo River in the city of Kalamazoo.

Age, level of education, and employment status of anglers interviewed in the two counties are presented in Table 5.

Age Distribution

Approximately two-thirds of all anglers interviewed were between 18 and 45 years of age. About 15% were between 46 and 60 years old; 6.6% over 60, and; 11.5% were under 18. The age distribution of anglers differed significantly between the two counties. A higher percentage of anglers under 18 years of age were interviewed in Allegan County (14.4% vs. 3.3%). There were fewer anglers from Allegan County in the 18-45 year age groups (62.5 vs. 78.3%). The percentage of anglers over 45 years of age was similar in both counties.

Education

Approximately one-third (33.8%) of all anglers interviewed had some college education or had graduated from college. This percentage was higher in Kalamazoo County than Allegan. Overall, about one third (31.8%) of anglers in the two counties had completed high school, without any added college education. Those with less than a high school education comprised 28.5% for the two counties combined; however, this number was higher in Allegan County (32.2%) than in Kalamazoo County (17.9%). The larger number of children under 18 years interviewed in

Allegan County partly explains the higher percentage of anglers who had not completed high school.

Employment

With regard to employment status, there were no statistically significant differences between anglers in the two counties. Of particular interest, however, is that nearly 20 percent of anglers interviewed (both counties combined) reported being unemployed. This is considerably higher than the statewide average for Michigan (5.7%), or the county averages for Kalamazoo (4.0%) and Allegan (3.7%) during that same 5-month period (15).

Objective 2: Determine the primary reasons for the use of this resource.

Table 6 includes survey findings relative to the primary reasons people fish the Kalamazoo River in Kalamazoo and Allegan counties. The majority of anglers (75.3%) in both counties responded that they fish primarily for recreation and enjoyment. This response was more common in Kalamazoo County than in Allegan County (87.6% compared to 71.0%). Almost 4% of Allegan anglers fished for food only, while none of the Kalamazoo anglers stated that they fish for food only. An additional 10.6% of all anglers responded that they fish both for food and recreation. It is not known how many anglers in these two groupings depended on sport-caught fish as a major source of protein in their diet due to economic reasons.

Approximately 50% (47.5) of the anglers had fished the river 6 times or more (Table 6) during the past year. Those who had fished the river 2-5 times comprised 18.4%. Less than 5% had fished one time only. Nearly 30% (29.4) had not fished the river at all during the previous year. There was no statistical difference in anglers' fishing frequency between the two counties.

In Kalamazoo County, 55% of the anglers indicated they had increased their fishing frequency from the previous year, while 42.6% of the anglers interviewed in Allegan County had increased frequency. About 10% of the anglers in the two counties had decreased their fishing frequency.

Fishing frequency was highest during the summer months with 94.7% of the anglers responding that they fished the river during that period. The spring season was second at 63.2%, followed by fall at 51.4% and winter at 16.0%. Fishing frequency was nearly equal between the counties during the spring and summer months, but was heavier in Allegan County during the fall and winter.

Objective 3: Determine fish consumption patterns of all anglers identified and assess their level of awareness of the sport-fish consumption advisories applying to the river.

Fish Consumption Patterns

Of the 938 anglers interviewed in Kalamazoo and Allegan Counties combined, about half (44.3%)

indicated that they eat fish from the Kalamazoo River or Portage Creek (Table 7). The percentage was higher in Allegan County (47.0%) than in Kalamazoo County (34.7%). Approximately 11% of the anglers reported eating turtles. About 11.3% of participants and household members reported eating fish from the river more than once per week. Some unknown fraction of these individuals may eat fish frequently enough to be subsistence anglers.

When asked if they practice "catch and release only," 73.5% of the anglers answered "yes." This response was received by 97.2% of the anglers in Kalamazoo County and 66.3% in Allegan. We anticipated that "the catch and release only" category would represent the anglers not eating fish from the river (100% minus those eating Kalamazoo River/Portage Creek fish), yet the percentages are much higher than the figures derived by subtraction. We assume that some anglers answered "yes" to this question if they release even a portion of their catch.

Most Popular Species

Anglers in both counties listed bass and catfish more often than any other as fish species which they target to catch. Catfish have been reported to have high-levels of PCBs and appear to be the most frequently consumed species (83.6%)(Table 7). In Kalamazoo County, a broader range of species were being targeted with walleye, pike, and panfish also being listed by more than 20 percent of anglers interviewed. Turtles were also much more frequently sought in Kalamazoo County than in Allegan County (13.5% vs. 1.2% of anglers)(Table 6).

Fish Meal Frequencies

About 11% of those anglers who reported eating fish from the Kalamazoo River responded that they eat fish from the river more than once per week; 14% approximately once per week; 34% once per month, and 41% less than once per month. Meal frequencies for consumption by household members of anglers was very similar to that of the anglers (Table 7). Table 8 shows that the mean number of fish meals (consisting of fish from river) consumed per year by study participants was 26.2 (approximately 2 meals per month). Also displayed in Table 8 is the average number of meals eaten by participants per year for eight of the common fish species found in the river, as well as turtles.

Fish Preservation

Anglers were asked whether they preserve any of their catch by freezing, smoking or canning for consumption at a later time (Table 7). The responses showed that 31.2% of the anglers do preserve some fish for later consumption. A much higher percentage of anglers interviewed in Allegan County preserved fish than in Kalamazoo County. Leading fish species preserved were catfish, panfish, bass, walleye and pike (Table 8). The average number of pounds per year preserved by these anglers ranged from 4.3 for suckers to 19.3 for Northern pike. About 15% of

the anglers who preserve fish also preserved turtles (Table 7). The annual number average of pounds of turtle preserved by those individuals was 25.(Table 8). It is assumed that this represents the total weight of the turtle rather than edible meat. The average number of meals of turtle eaten per year by these individuals was four.

Nearly 40 % (Table 7) of anglers interviewed in the two counties indicated that family members also eat fish brought home from the river. Seventeen percent reported giving some fish to friends. Species most often eaten by the anglers were catfish, bass and panfish. Consumption patterns differed greatly between the two counties. Kalamazoo County anglers tended to eat all species, but suckers and carp were the least frequently listed at 58.8% and 66.7%, respectively.

Concern About Safety/Awareness of Sport Fish Consumption Advisory

In Kalamazoo County, 71.8% of anglers interviewed responded that they were concerned about the safety of eating fish from the river (Table 6). This is statistically higher than for Allegan County (59.9%). A majority of anglers in both counties report that they practice some catch and release; 97.2% for Kalamazoo County and 66.3% for Allegan County (Table 7). The survey showed a higher awareness of fish consumption advisories in Kalamazoo County as compared to Allegan County (63.9% vs. 40.0%). Of all anglers interviewed, 27.5% accurately identified MDCH as the organization that issues fish consumption advisories. This was higher in Kalamazoo County at 41.6%, with only 23.2% in Allegan County properly answering the question. We believe many anglers responded that MDNR issues the advisories rather than MDCH because the advisory appears in the MDNR Michigan Fishing Guide.

If the river was to be cleaned up to the point that fish consumption advisories are eventually removed, approximately 60% of the anglers indicated their fishing behavior on the river would not be affected. About 25% overall indicated they would make more trips to the river and fewer to other locations; and 15% would increase fishing in the Kalamazoo River without reducing trips to other bodies of water.

Objective 4: Identify persons other than the anglers who may be consuming significant quantities of fish from the river which they received as gifts from anglers or obtained otherwise.

Anglers typically share fish they catch with other household members. Relatives and friends outside the family may also occasionally receive fish as gifts from anglers. Table 7 reports the percentage of respondents in each of the counties who indicated that they give fish to relatives and friends. The overall rate was 17.0% for both counties combined, with the frequency in Kalamazoo County much higher (38.5%) than the frequency among the anglers interviewed in Allegan County (15.8%).

Fish Consumption by Other Household Members

Fish meal frequencies by household members of anglers was very similar to the frequency by the anglers themselves (Table 7). On the average, households of Kalamazoo River anglers had 1.8 adults who eat fish, 1.3 children of ages 5 - 18 years, and 0.3 children under age 5 (Table 8).

Objective 5: Determine willingness of persons identified above to participate in follow-up health studies and obtain addresses and telephone numbers of those who are willing to participate.

Anglers were asked if they would be interested in participating in a follow-up study which would include a health questionnaire and testing of blood for PCBs, DDE, and mercury. Approximately half of the surveyed participants responded affirmatively and provided their address and telephone number so they could be contacted later. A slightly lower percentage responded positively in Kalamazoo County (43.3%) than in Allegan County (50.9%) (Table 6).

Objective 6: Develop a list of fish consumers for participation in PHASE II activities.

A total of 459 anglers indicated they would be interested in participating in a follow-up study. Project staff, however, were only able to successfully locate 151 of these for PHASE II of the project. This provided an overall locating rate of 33% and a 100% participation from the located individuals. Participation in PHASE II was 69% (n = 104) for Allegan County and 31% (n = 47) for Kalamazoo County.

Discussion

Most anglers were very cooperative with the survey teams and expressed interest in the survey. However, participation by anglers in Allegan County was considerably lower (81.6%) than in Kalamazoo County (97.9%). It is not known what impact the lower participation rate in Allegan County may have on the findings in terms of sampling bias. Access to the Kalamazoo River on Lake Allegan is available at a number of locations through public land which is part of the Allegan State Game Area. Anglers encountered in Allegan County were from a diverse geographic area which included not only Allegan County residents but residents of a large number of southwestern Michigan communities and residents of Indiana and Illinois. This could account for the low percentage of people who could be located/traced for follow-up activities. It is also probable that anglers who were not residents of the area would have less interest in the survey.

The age composition of the angling population was similar to that found in a survey of the Tittabawassee River, Midland County, in 1987 (12). The Tittabawassee River survey was conducted one year after some long-standing advisories had been relaxed by the MDPH. Ages of anglers encountered was compared to the age structure for the respective counties and the state as determined in the 1990 U.S. Census (13). The Allegan County population data showed 29.7%

to be under 18 years of age, compared to the angler population percentage of 14.4%. A larger difference was noted for Kalamazoo County, where the segment of the total population under 18 was 24.4% and the angling population showed only 3.3%. The statewide population under 18 years represents 26.5% of the total. population

A review of the education level attained by participants in the Kalamazoo River Angler Survey showed differences between anglers interviewed in Kalamazoo County vs. those in Allegan County, with Kalamazoo County anglers generally having a higher level of education. This may have partly been due to a higher percentage of anglers in Allegan County being in the age group of less than 18 years old. For another comparison, we looked at education data available for 1990 at the county and state level. The census data show that Kalamazoo County residents 25 years of age or older had attained a higher level of education (55.7% with some college or a college degree) than the same age group in Allegan County (35.0%) or for the state (44.5%). Interestingly, a statewide mail survey of licensed anglers conducted in 1991-92 by West et al. showed that education level was not a significant factor in mean fish consumption rates of Michigan anglers (14). This relationship for the Kalamazoo River will be evaluated more fully in the PHASE II portion of this report.

The unemployment rate for anglers in Allegan (20.5%) and Kalamazoo (17.4%) Counties was much higher than the overall unemployment rates for their respective counties (Allegan County 3.5%; Kalamazoo County 3.9%) based upon Michigan State Security Commission (MESC) data (15) over the same 5 month period in 1995. The statewide rate for 1995 was 4.9% (15) In a similar survey conducted on the Tittabawassee River in 1987, 16.2% of the anglers reported being unemployed, which is slightly lower than found in the Kalamazoo River survey (19.7%).

A higher unemployment rate in a population of anglers may be expected since people who are unemployed would have more time to devote to this pastime and also because some may be depending upon fish to supplement their diet (subsistence anglers). However, it is important to recognize how the survey question was structured in comparison to the MESC methods of computing county and state unemployment rates. The MESC labor force statistics exclude the following: 1) children under 16 years of age, 2) people in the armed forces, 3) people no longer seeking employment, 4) housewives, 5) people institutionalized, 6) and people lacking transportation. The survey question (Appendix B, Q #16) required each angler to select one of five choices: employed full-time, employed part-time, self-employed, unemployed, or retired. The fact that the exclusions used by MESC were not applied in the survey would likely account for a major portion of the differences in estimated employment rates. With the survey being conducted during the period of May through September, seasonality may also be a factor. MESC statistics adjust for seasonality in calculations for statewide unemployment rates but not for county rates.

A very transient group of approximately six anglers and their families were observed fishing the Kalamazoo River, in Kalamazoo County, throughout the spring and summer of 1994. This group had no permanent address or phone number. It was perceived that some members of this group of anglers migrated from the southern states to Michigan during the warmer months of the year.

They appeared to subsist mainly on fish caught from the Kalamazoo River.

During the spring and early summer of 1995, the Kalamazoo County survey team made routine trips along the Kalamazoo River in an attempt to make contact with the transient group of anglers observed in 1994. No contact was made with this group and efforts were ceased on June 7, 1995.

A large number of anglers who fished from the bank were unaware of the fish consumption advisory. Anglers fishing from a boat were more likely to be aware of the fish consumption advisory. Although the survey did not collect data on income levels, surveyors felt there is most likely a socioeconomic difference between bank and boat anglers.

There seemed to be a difference in the populations utilizing different portions of the river. Parts of the river in Kalamazoo County are very urban. The surveyors observed that many persons walked to the river. They also noticed that some individuals would avoid making contact with the survey team, leaving the area as the team worked their way towards them. The team interpreted these actions as indicating that such individuals were probably not licensed to fish and perceived the interviewers to be conservation officers. With repeated survey attempts in the same locations, previous interviewees recognized the survey team and offered tips as to where additional anglers might be located. Despite the noted avoidance by a few anglers, the participation rate was high in Kalamazoo County (97.9%).

In Allegan County, the river is primarily rural in nature. The Allegan team found that most of the population using the river drove to it. Lake Allegan was found to be heavily utilized, with boats being used by most of the persons fishing that portion of the river. The team also noted that most anglers, when they were approached, were pulling out their fishing licenses for checking. In both counties, the surveyors tended to be well received. The participation rate in Allegan County (81.6%) was lower than in Kalamazoo County, probably due to lower interest by visitors to the area.

Only 46.2% of the anglers indicated an awareness of the fish consumption advisories in effect for the Kalamazoo River. West, et al. in 1992 had found 41.9 percent of anglers statewide were aware of specific advisories, but an additional 45.4 percent were generally or vaguely aware of advisories (14). Both surveys indicate the need for more extensive publicity about advisories in specific bodies of water. Since completion of this survey, MDCH has worked cooperatively with the Kalamazoo River Area of Concern (AOC) citizens committee in more broadly publicizing the advisories locally. Signs have been posted at 14 of the most popular fishing sites and a pamphlet developed by the AOC group has been printed and distributed (16). MDCH has also developed a draft *Recreation Guide for the Kalamazoo River*, which focuses primarily upon fish consumption advisories.

One of the objectives of the study was to identify a large enough population for conducting a PHASE II follow-up exposure and health history investigation. Despite having the names, addresses and telephone numbers of people who indicated a willingness to participate in follow-up

studies, project staff had difficulty reaching many of these anglers during enrollment for the PHASE II study. Many people had moved or did not respond to repeated telephone calls.

Conclusions

1. Some statistically significant differences were found between descriptive characteristics of anglers from the two counties. Anglers from Allegan County were younger and were less educated when compared to Kalamazoo County anglers. The average level of unemployment among anglers in both counties was considerably higher than statewide employment rates.

2. A majority of the anglers indicated that they fish primarily for recreation and enjoyment. Kalamazoo anglers preferred to fish during the spring and summer months, whereas anglers from Allegan County tended to fish throughout the year. Anglers (4%) from Allegan County reported fishing as a source of food.

3. About 75% of the anglers surveyed eat fish from the river no more often than one meal per month. Slightly more than 10% of the anglers report eating fish more often than one meal per week. A high percentage of the anglers (73.4%) practice some catch and release behavior. Even species that appear in the MDPH "Do Not Eat" advisory category are frequently kept for consumption. Fewer anglers from Allegan County were aware of fish consumption advisories. Anglers identified in the survey reported eating Kalamazoo River fish for an average time of 10 years.

4. Kalamazoo anglers were more likely to share fish with household members and friends while Allegan anglers more frequently preserve fish for later consumption.

5. PHASE I of the survey confirmed that an adequate number of people were consuming fish from the Kalamazoo River to provide a scientifically defensible sample for the PHASE II biological testing and health survey. Almost 49% of the 938 participants interviewed indicated an interest in a follow-up study that investigated the concentration of PCBs and other residues in blood samples from anglers and evaluated their self reported medical histories. These anglers constituted the list of potential participants for the PHASE II study. No anglers were found to be using the contaminated zone of Portage Creek.

Recommendations

Extensive publicity about fish consumption advisories that apply to the Kalamazoo River are recommended.

PHASE II
Health Survey and Biological Testing

Introduction

In the early 1970's, the contaminated areas of the Kalamazoo River and Portage Creek were almost devoid of fish. With the improvement of water quality over a period of time, a diverse fish population has developed. Despite continued fish consumption advisories, local health officials have observed frequent fishing activity within the contaminated zone during the early 1990's. Although some contaminant residues in fish from these waters have been decreasing, there are lingering concerns that consumption of these fish may have potential public health impacts.

Background

The first phase of this study was initiated in May 1994 and completed in September 1994 and was conducted in Kalamazoo and Allegan Counties. The Angler Survey attempted to characterize the sport anglers and other people who regularly eat fish from the affected portions of the Kalamazoo River and Portage Creek and identified fishing patterns. This was accomplished by using an 18-item survey questionnaire.

Recreation and enjoyment were the reasons given by most anglers (75.3%) for why they fished. Fishing frequently was highest during the summer, followed by spring, fall and winter in descending order of frequency. Anglers in both counties listed bass and catfish most often as fish they wanted to catch. The mean number of fish for all study participants was about two meals per month. The awareness of fish consumption advisories was 63% in Kalamazoo County and 40% in Allegan County. Most of the anglers interviewed (72.5%) mistakenly thought that the Michigan Department of Natural Resources (MDNR) issued advisories, perhaps because the advisory appears in the MDNR Michigan Fishing Guide.

The fish meal frequency indicated by household members was similar to the anglers themselves. An average of 17% of respondents from both counties said they gave fish to friends. This frequency was higher in Kalamazoo County (38.5%) than in Allegan County (15.8%). The first phase survey confirmed that an adequate number of people are consuming fish from the Kalamazoo River to provide a scientifically defensible sample for the second phase Follow-Up Biological Testing and Health Survey. Approximately 49% of the 938 surveyed anglers expressed an interest in the follow-up study.

Specific Objectives

1. Enroll consenting Kalamazoo River fisheaters who participated on PHASE I Angler Survey into a study cohort.

2. Obtain individual self-reported medical information and fish consumption patterns.

3. Perform chemical residue analyses on blood samples and report measurable levels of PCBs, DDE, and mercury and to determine if these levels are of public health concern.

4. Analyze for possible associations between chemical residue levels and self-reported health problems of fish-eaters.

5. Compare chemical residue data from this study cohort to other fish eating populations previously studied

Methods

Enrollment

Individuals who were identified and interviewed in PHASE I and those who expressed their willingness to participate in the biological testing part of the study constituted the roster of candidates for PHASE II. Attempts to locate these volunteers for participation in PHASE II activities included making repeated telephone calls, sending information letters, conducting home visits, and contacting neighbors. Consenting anglers who were successfully traced and located constituted the study population for PHASE II activities.

Questionnaire

After obtaining a written consent, a standardized 'Fish Consumption and Health Conditions Survey Questionnaire' (Appendix C) was administered to PHASE II study participants in 15 minute interviews by employees of the Kalamazoo and Allegan County Health Departments. This questionnaire elicited information on fish consumption patterns and self reported medical conditions.

Biological Testing

After obtaining written consent, biological testing was performed to estimate serum levels of PCB and DDE congeners. Fifteen milliliters of whole blood was obtained by venipuncture to assure a sufficient volume of serum was available from each study participant. Additionally, 10 milliliter samples of whole blood (heparinized) were collected for mercury analysis.

The analytical method used by the laboratory has been modified and adapted to our laboratory's requirements from the method published by Needham *et al.*, "Temperature-Programmed Gas Chromatographic Determination of Polychlorinated Biphenyls in Serum." The development of this method was a cooperative effort between the CDC in Atlanta, Georgia and the laboratory (17). Our modified method uses multiple extractions with mixed solvents, a Florisil cleanup column and a Silica Gel 60 column for fractionation and isolation of contaminant residues. A congener-specific procedure was employed for quantitation of PCB using capillary gas chromatography. Details of the extraction procedures and analytical methods used can be found

in Appendix I.

Determination of mercury in blood samples was done following an accepted method for total mercury measurement using cold vapor atomic absorption spectroscopy. This sensitive and specific technique reduces mercury ions in an acidified digest to neutral mercury atoms with stannous chloride. The mercury atoms were stripped from solution by a flow of argon. The mercury vapor is then presented to an absorption cell in the light path of an atomic absorption instrument.

Organochlorine pesticide exposure determinations were done by analyzing for DDE levels in the blood specimens as an indicator of DDT exposure from fish consumption.

Statistical Data Analysis

SPSS Version 6.1.3 was used for analysis of the data. Univariate analysis was performed to provide a summary of descriptive statistics for each county. Descriptive statistics used to characterize continuous variables included means and standard deviations. Frequencies were used to characterize categorical variables. Laboratory values of all contaminants reported as less than the detectable limit were not included in the data analysis. To improve normality of distributions for statistical analysis, all laboratory measurements were transformed to their logarithm scale.

Chi-square test was employed to evaluate relationships between categorical variables. Two-sample t-test was applied to assess the association between continuous variables. Simple logistic regression was used to examine the relationship between laboratory measurements and questionnaire variables of interest. This approach was used to predict the value of a dependent variable (PCB total, DDE or mercury) with a single independent variable. Odds ratios representing the odds of elevated serum levels in an exposed participant relative to an unexposed participant were calculated to estimate the relative risk for having elevated PCB total, DDE and mercury levels. The outcome variable was defined as an elevated PCB total (≥ median: 1.40 parts per billion [ppb]), elevated DDE (≥ median: 2.20 ppb) or elevated mercury (≥ median: 2.80 ppb). Multiple logistic regression was used to assess the strength and direction of relationships between elevated contaminant levels and selected independent variables (see Appendix G for the coding system).

The procedure included variables in the model which were of interest to the investigators. Associations were considered statistically significant if the p value was less than 0.05.

Results

The PHASE II Health Survey and Biological Testing results are discussed in relation to the project objectives.

Objective 1: Enroll Kalamazoo River Fisheaters in a Study Cohort.

Of the anglers surveyed in PHASE I, 49% of 938 expressed an interest in participating in the follow-up study. Of the 459 who expressed interest, the counties were able to locate and trace only 151 members resulting in a locating rate of 33%. Clearly, the participation rate is very small. Calculations for the inference of biological results based on the current sample indicated that all power estimates for detecting the differences between PCB and DDE level groups were less than 80%, the traditional acceptable lower limit at an alpha level of 0.05. A total of 151 fish consumers were successfully enrolled in the PHASE II of the Health Survey and Biological Testing Study. This study cohort was comprised of 104 Allegan County and 47 Kalamazoo County participants. These participants were predominantly white (86.6%) and male (75.5%), as seen in Table 9. It should be noted that due to technical errors in the analytical laboratory blood serum samples from these participants yielded only 144 test results (Appendix J).

The group of anglers from Kalamazoo County had a higher level of education than those from Allegan County (Table 9). But, there were no significant differences between the two counties in terms of age, race or sex. Factors that would help explain the difference in levels of education were not apparent. Demographic information in Appendix D indicates that participants in the biological testing portion of the study did not differ significantly whether they were from Allegan or Kalamazoo County.

Objective 2: Obtain Individual Self-Reported Medical Information and Fish Consumption Patterns.

A percentage distribution of health-related characteristics reported in Table 10 reveals a significantly high rate of smoking (51.7%) which is about twice the overall average for the State of Michigan (25.4% in 1994) based upon the draft report of Health Risk Behaviors - 1994. Consumption of alcoholic beverages was self-reported by PHASE II participants as 68.7% (presently consume alcohol) which compares to a statewide average of 56.7% (any consumption in the previous month) recorded in the Health Risk Behaviors - 1993 report. Additionally, over 59% of the cohort indicated that their weight had increased. These are major health concerns seen in the general population today related to personal behavior. Also seen in Table 10, there are indications of potential exposure to industrial chemicals; 55.6% answered "yes" when asked if they were ever exposed, and 48.3% answered that they had been exposed to farm chemicals.

The most frequently self-reported medical problems are listed in decreasing order of occurrence in Table 11. A complete listing of all health conditions included in the PHASE II questionnaire (Appendix C) and their percentage distribution is presented in Appendix E. Anglers in Allegan

County were more likely to have had any type of allergy, coughing up of phlegm as well as having had persistent headache. Anglers in Allegan County did not differ significantly from the anglers in Kalamazoo in terms of other medical problems. Validation of self-reported health conditions by a review of medical records was beyond the scope of this study.

Comparisons of fish consumption by county in terms of fish eaten in the past year (9.6 lbs. Allegan vs. 6.0 lbs. Kalamazoo), mean years of eating fish (11 vs. 16), and consumption in past years showed quite similar patterns in both counties (Table 12). The percentage distribution of fish consumption characteristics in the past year between the counties showed no significant difference either (Table 13).

The associations between selected demographic characteristics and fish consumption are presented in Tables 14 and Table 18. These tables show a consistently high rate of smoking among anglers (51.2%-58.7%) who reported eating fish in the past year. Non-white anglers were more likely to eat sport caught fish in the past year than white anglers (Table 14). A review of age association with the consumption of ≥ 12 fish meals in Table 15 indicates that older people tend to eat more meals of fish than anglers who are < 31 years of age. Table 16 shows there was an association between age and years of fish consumption. However, the large standard deviations indicate a high variability of years relative to the means for the 31-45 years of age group. The associations between selected demographic characteristics and fish consumption presented in Table 17 are remarkable in that the standard deviation exceeds the mean in each case. In Table 17, there are significant differences between both drinking status and weight change in the past year but no relationship with awareness of fish advisories and fish consumption in pounds in the past year. Table 18 presents no significant difference between the selected characteristics and the amount of fish consumption in the past year. Also, Appendix F indicates that participants from the two counties do not differ in fish consumption characteristics except for skinning of fish in Kalamazoo County. Results are inconclusive for fish consumption characteristics other than skinning fish because of the small number of cases.

Objective 3: Perform Chemical Residue Analyses on Blood Samples.

Analytical laboratory test values for participants are shown in Table 19. When Allegan and Kalamazoo Counties were compared, chemical residue analyses showed no significant differences in terms of total PCB, DDE or mercury blood contaminants using the student T-test and presented in parts per billion (ppb). Overall, increasing residue levels for PCB and DDE suggested a good correlation with increasing age (Table 20). This may have reflected the persistence of these compounds in human tissues and possible higher past exposures. Mercury on the other hand showed no such positive correlation with increasing age. This may have been due in part to its much shorter half-life (60-90 days) in the human body and lack of statistical power. Table 21 indicated significantly higher PCB and DDE residue levels in fisheaters compared with non-fisheaters. There was no association between mercury residue levels and fisheaters. (Fisheaters were defined as participants who ate Kalamazoo River fish in any amount.)

Median serum contaminant level was used as a measure of central tendency. The simplest division of a set of measurements is into two parts, which are the lower and the upper halves. The point on the scale that divides the group in this way is called the median (18). P-values were calculated to determine if serum contaminant levels were associated with selected demographic characteristics (Table 22) and fish consumption levels (Table 23) using median serum contaminant levels and chi-square analyses. Unadjusted odds ratios were calculated to determine if serum contaminant levels were associated with selected fish consumption factors (Table 24) and selected demographic characteristics (Table 25) using simple logistic regression analyses. Adjusted odds ratios were calculated to determine if selected demographic characteristics were associated with serum PCB levels (Table 26) and serum DDE levels (Table 27) using multiple logistic regression analyses. The p-value and odds ratio calculations included in this report supported the findings indicated thus far. Elderly anglers were more likely to exceed the median level for total PCB. Female and non-white anglers were more likely to exceed the median DDE level. Fisheaters were more likely to exceed the median for PCB or DDE levels.

As reported in Table 23 it was observed that anglers who reported eating fish in the past year were more likely to exceed the median total PCB and DDE levels than anglers who did not report eating fish. There was also a significant difference in the median mercury levels among the fisheaters who reported eating at least 12 or more fish meals in the past year.

A review of unadjusted odds ratio (Table 24) between fish consumption and levels of blood contaminant concentrations indicated that individuals who reported consumption of fish in the past year were two to three times more likely to exceed the median levels of contaminants (DDE vs. PCB's) than individuals who reported no fish consumption in the past year. A review of unadjusted odds ratios for selected demographic characteristics (such as age, race, and sex) produced consistent results indicating that, for older individuals, non-whites, and females, contaminant levels exceeded the median levels when compared to younger, white, or male anglers, respectively, in the aggregate group.

A multiple logistic regression of the variables of interest (such as age, education, race, sex, smoking status, drinking status, and self-considered health status) (Table 26) substantiated the earlier findings. Age (older), race (non-white), sex (female), current or prior smoking, and current or prior drinking were independently associated with PCB levels exceeding the median value at a statistically significant level ($p<0.01$). There was no observed association between fish consumption in the past year and levels of PCBs, (Table 26).

Objective 4: The Possible Association Between Contaminant Residue Levels and Self-Reported Medical Problems.

Medical problems reported as subjective symptoms (such as upset stomach, nausea, headache, or dizziness) were not measurable or quantifiable in an objective way. In addition, verification of the reported medical problems was not possible in this study. Therefore, statistically significant associations were not found between contaminant residue levels and self-reported medical

problems. However, those anglers who considered themselves to be in good health appeared to be less likely to have blood PCB levels exceed the median values for the aggregate group than anglers who considered themselves to be in fair/poor health (Table 26).

Objective 5: Compare Chemical Residue Data from This Study Cohort to Other Fish Eating Populations Previously Studied.

The Kalamazoo Angler Survey provides a representation of persons consuming stream caught fish. Most of our previous experience has focused on large-lake, open-water-fish-eaters. Streams are easier to access and require less monetary investment to fish than open water fishing. The Kalamazoo River Study provides a unique insight to a subpopulation group who may face different exposure risks because of habitual use of contaminated segments of the river which are easy to get to and can be fished at low cost from the river bank.

Lake Michigan open-water-fish-eaters were first evaluated in 1979-80 (19) when a cohort of 572 persons eating 26 lbs. /year or more of sport-caught fish were evaluated and compared to 419 randomly selected comparisons who ate 6 lbs. /year or less. The fish-eaters had a median PCB level of 21.4 ppb (range 3-203) and a median DDT (measured as DDE) level of 26.4 ppb (range 1-513). In contrast, the "non eaters" had respective medians and (ranges) of 6.6 ppb (3-60) and 10.5 (1-91).

Part of this cohort was reevaluated in 1989 (20). PCB levels were relatively unchanged (fish-eaters, 19 ppb, and "noneaters" 6.3 ppb), although DDT (measured as DDE) had declined in both the fisheaters (15.6) and the comparison group (6.8 ppb).

In contrast to the previous work, Kalamazoo River fish-eaters of the 1990's have a significantly lower exposure to PCB (mean serum below 5 ppb) and DDE (mean serum below 5 ppb). This is not unexpected since the Lake Michigan open water study selectively enrolled fish-eaters who ate "significant" quantities of sport-caught fish (the group averaged 32 lbs. . or 64 meals per year consumption). In contrast, the Kalamazoo River Study participants, averaging about 9 lbs. or 18 meals per year, ate far less fish. In fact, Kalamazoo River "fish-eaters" ($\geq$ 6 lbs. . or $\geq$ 12 meals per year) have serum PCB and DDT levels which more closely resemble the comparison group (6 lbs. or less per year) for the Lake Michigan study. The mix of fish caught and consumed represents a second reason river fish-eaters might be expected to experience less PCB and DDT exposure than open-water-fish-eaters. The latter group sought and consumed large predator species such as lake trout and salmon, which on average have had significantly higher historic and current PCB and DDT contamination than river species. Examination of Table 4 of this report reflects this as species collected from the river no longer exhibit the excessive PCB levels recorded in collections a decade or more ago.

A Wisconsin angler survey in the 1980's (21) provided an appropriate comparison for the Kalamazoo study because it was primarily focused on anglers of inland lakes and rivers. Tests on 192 of these anglers showed mean serum PCB levels of 2.2 ppb and DDE levels of 6.3 ppb, with

59 persons recording no detectable PCB. The survey of Wisconsin anglers from which the 192 were selected averaged about 18 sport-caught-fish meals per year (21). Another Wisconsin study was conducted to examine serum PCB and DDE levels of frequent Great Lakes sport fishermen (22). The study found significantly higher serum PCB levels in a group of Great Lakes sport-caught-fish (GLSCF) consumers (geometric mean: 4.8 ppb males, 2.1 ppb females) as compared with non-consumers (geometric mean: 1.5 ppb males, 0.9 ppb females). The study also found higher serum DDE levels in GLSCF consumers as compared with non-consumers (22). In addition, serum PCB and DDE levels were significantly correlated to age, body mass index, and sport fish and GLSCF consumption histories (22).

In comparison to the Wisconsin inland lakes and rivers study (21), the Kalamazoo River fish-eaters had slightly higher mean serum PCB levels. This was expected because the Kalamazoo site was polluted and the Wisconsin sites were not. The higher risk of exposure from the Kalamazoo River fish was reflected in three ways: 1) the Kalamazoo River anglers on average ate less fish (half ate less than 12 meals per year as compared with an average of 18 in Wisconsin) but had higher mean PCB levels; 2) 59 of the Wisconsin anglers had no detectable PCBs while only 10 Kalamazoo River anglers were non-detectable; and 3) the upper range of serum PCBs (73 ppb) reported in Kalamazoo was more than two and one-half times the upper range seen in Wisconsin (27.1 ppb). The Wisconsin Great Lakes sport fishermen study (22) found higher geometric mean PCB levels in GLSCF consumers and approximately equivalent geometric mean PCB levels in non-consumers then with the Kalamazoo study.

Mercury exposure from consumption of Kalamazoo River fish does not appear to be a problem. For those tested, 113 persons had no detectable serum mercury, and the 33 persons with detectable levels averaged 3.43 ppb, with a top value 9.6 ppb. This is consistent with our earlier open-water-fish-eater studies where mercury is not commonly detected. In contrast, human serum levels for fish-eaters (≥26 lbs./year) consuming fish from waters known to be contaminated with mercury (Lake St. Clair in the 1970's) were significantly higher (mean 36.4 ppb, range 3-96 ppb) (23). In contrast, a comparison group (0-6 lbs./yr) for the St. Clair study had a mean serum mercury of 5.2 ppb, with a range of 1.6 to 11.5 ppb, which is comparable to and slightly above the levels found in the current Kalamazoo River cohort.

In summary, the Kalamazoo River fish-eater survey demonstrated that people who use this river as a food resource have moderate PCB and DDE exposure which is less than that found in the past for open water Great Lake fish-eaters. The PCB and DDE levels found are moderated by the relatively low frequency of fish consumption reported in the study. If consumption rates were to increase to levels reported in comparable studies, a concomitant increase in organic chemical exposure would be expected.

Discussion

Clearly, the participation rate (151/938) was small. Calculations for the inference of biological results based on the current sample indicated that all power estimates for detecting the differences

between PCB and DDE level groups were less than 80%, the traditional acceptable lower limit at an alpha level of 0.05. It is well known that two-phase studies encounter small participation rates when follow-up interviews are required. It is possible that those who participated in this study were not representative of the larger population of fish anglers.

A comparison of general characteristics between the PHASE I and PHASE II cohorts in Appendix H reveals that the two groups were similar with respect to educational level, having eaten fish in the past year, and the number of years they had eaten Kalamazoo River fish. But, anglers who participated in PHASE I were more likely to be younger, and they were less likely to be aware of the fish consumption advisory covering the Kalamazoo River. PHASE I interviews were done primarily in the spring and summer when younger school age anglers could be fishing. By contrast, PHASE II was conducted in the winter when younger participants were back in school. The increased awareness of the fish consumption advisory among PHASE II participants could be explained in part by increased awareness as a result of their participation in PHASE I.

This study's serum data showed that increased Kalamazoo River fish consumption was positively associated with increased PCB and DDE serum concentrations and with increasing age. But, no positive associations could be measured between PCB and DDE serum levels and the self-reported medical problems listed by the anglers. When the significantly associated variables of interest were controlled in a multiple logistic regression model, the fish consumption variable appeared to be minimally associated with levels of PCBs that exceeded the median value. Irrespective of the relationship between the serum levels of the contaminants of concern, it has to be noted that some of the levels observed in this population exceeded the average levels found in non-occupationally exposed groups. The long-term health impacts of these levels are unclear at this time. A longitudinal study of anglers subsisting on sport caught fish may provide an insight into the potential for health effects from environmental exposures through consumption of contaminated fish.

For more than 20 years Michigan has issued a sport-fish consumption advisory annually for portions of the Kalamazoo River. The advisory has provided anglers with information on how to minimize exposure to PCBs while still enjoying their catch. Our study survey results indicate that these efforts in reaching anglers in Michigan with sport-fish consumption advise can be improved. Only 46.2% of the anglers in our study indicated an awareness of the fish consumption advisories in effect for the Kalamazoo River. More effective means of communicating the fish consumption advisory could potentially help lower the residue levels of PCBs and DDE among Kalamazoo River fish-eaters. Compared with subjects who did not agree to participate in blood analysis, participants were more likely to be older and highly educated. Since the relationship between age and PCB/DDE level was positively associated, the findings from the study may be overestimated a bit. There is no statistically significant difference between participants and non-participants in terms of concerns about safety of eating Kalamazoo River fish and fishing frequency change in the study year.

The survey of self-reported medical information reveals a significantly higher rate of smoking

among anglers at 51.7%, as compared to the statewide average in Michigan of 25.4% reported in the draft report on Health Risk Behaviors - 1994. Potentially, one benefit to the Kalamazoo River anglers that could result from our study would be an effective smoking cessation program that reduced the known health risks due to smoking.

Limitations

The investigators obtained blood samples from an angler population that was not randomly selected. Therefore, the study results may have contained selection bias, and the study participants may not have been indicative of the general population. Also, fish consumption within the past 12 months from the date of questionnaire response was used as the exposure variable. A 12 month fish consumption history is more indicative of short-term exposure, whereas a long-term fish consumption history is possibly a more appropriate variable regarding cumulative PCB and DDE body burden. This is because PCBs and DDE bioaccumulate slowly over many years of exposure and are environmentally persistent. Category names such as "recent Kalamazoo River fish-eater" and "not recent Kalamazoo River fish-eater" would have improved the descriptions of the groups. Also, dietary recall bias may have been introduced into the study. Participants were asked to recall their fish consumption over the previous 12 months using questionnaire responses. In addition, PHASE II may have included response bias because the participants knew the purpose of the study. However, in a two-phase epidemiology study, concealing the purpose of the study is difficult.

More thorough demographic descriptions of the fish-eater and non-fish-eater groups would have been helpful in the analysis of the PHASE II objectives. This would have included demographics, such as age, race and sex. Also, many study participants did not supply their age during the interview, which was especially important because of the association of serum PCB levels and age. Demographic descriptions of the persons not included in PHASE II would have also been helpful to determine if differences between those not included in PHASE II and those included in PHASE II were present.

The heath effects studied were self-reported. Self-reported health effects can be misleading because low-level exposures to certain contaminants may lead to subclinical health effects that the participant does not detect. In addition, self-reported health effects data present data quality and reliability problems that are not present in data compiled from patient records and vital record databases.

Conclusions

This investigation was undertaken to evaluate PCB, DDE and mercury exposure in sport anglers who fish the affected portions of the Kalamazoo River. The primary public health concern examined in this study was whether exposure to PCB, DDE and mercury through contaminated-

fish consumption significantly influenced levels of these contaminants in blood, and whether concomitant changes in health conditions would be reported by the participants.

1. Kalamazoo River fish-eaters were likely to have significantly higher residue levels of total PCB and DDE than non-fisheaters. When the effects of potential confounders (such as age) were accounted for, the observed association between PCB and DDE levels and fish consumption was not statistically significant. However, it is a public health concern that consuming contaminated fish has the potential to contribute significantly to the body burdens of PCB and DDE.

2. Analysis restricted to anglers with detectable mercury levels showed that fish consumption did not influence the level of mercury in the blood. It has to be noted that the proportion of subjects with non-detectable levels was similarly distributed among fish-eaters and non-fish-eaters.

3. No associations were observed between contaminant levels in blood and self-reported medical problems. The small sample size precluded further analysis for statistical significance.

4. A large number of anglers (53.8%) who fish the affected zone of the Kalamazoo River were unaware of the fish consumption advisory.

5. Smoking was more prevalent among anglers than the general public.

Recommendations

1. It is recommended that risk management decisions include continued testing of river fish for contaminant levels. Risk managers must ensure that contaminants in the affected zone of the Kalamazoo River and river sediments are at levels that do not represent public health concern.

2. It is recommended that the Michigan Department of Community Health and the county health departments develop more effective means of communicating the fish consumption advisory and ensuring compliance.

3. It is recommended that smoking cessation programs be made available specifically to anglers by state and local health departments.

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After completion of the field survey of anglers and the laboratory analysis of blood serum for residues, the responsibility for the project was transferred from Arthur W. Bloomer to Elroy C. Klaviter, Ph.D.

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Tables: 1-27

Table 1. Concentrations of PCBs in Water From the Kalamazoo River and Portage Creek.

Location	Date	Maximum Concentration (ppb)
Portage Creek	5/6/85	0.283
	7/29/85	0.335
Kalamazoo River	4/18/85	0.126
	5/20/85	0.062
	6/24/85	0.193
	7/22/85	0.110
	10/15/85	0.042
	5/13/86	0.153
	6/24/86	0.044
	3/24/87	0.041
	5/20/87	0.097

Reference: 2
ppb: Parts per billion

Table 2. Concentration of PCBs in Sediment From the Kalamazoo River and Portage Creek.

Location	Date	Maximum Concentration (ppm)
Bryant Mill Ponds	1972	368.7
	11/2/83	582.0
	4/3/84	898.0
	10/15/85	530.0
	8/6/86	980.0
	1987	74.0
	6/22/88	1,000.0
	6/24/88	440.0
Portage Creek	1972	117.61
	8/76	55.58
	11/82	85.0
	11/83	15.0
Kalamazoo River	8/76	66.6
	11/82	57.0
	6/83	81.0
	11/83	55.9
	1984	13.0
	5/29/85	57.4
	1987	120.0
Lake Allegan	8/9-10/76	24.67
	11/83	41.7
	1987	14.0

Reference: 2
ppm: Parts per million

Table 3. **Selected Total PCB Concentrations Found in Fish From Portage Creek and the Kalamazoo River.**

Species	Location	Date	Maximum Concentration (ppm)	Reference
Bass	Lake Allegan	8/76	2.4	2
		9/81	2.2	2
		7/85	6.54	2
Bullhead	Lake Allegan	7/71	10.65	1
Carp	Bryant Mill Ponds	7/85	4.5	2
		7/86	27.37	2
		7/14/87	5.5	2
	Portage Creek	9/81	1.0	2
	Kalamazoo River	7/71	164.5	1
		6/76	13.8	2
		8/76	11.8	2
		9/81	9.2	2
		7/83	15.9	2
		7/85	12.5	2
		7/86	11.09	2
		7/14/87	17.12	2
		10/13/93	9.6	3
	Lake Allegan	7/71	7.32	1
		8/76	7.4	2
		9/81	47.0	2
		7/83	5.03	2
		7/85	14.0	2
		7/86	13.34	2
		7/14/87	6.14	2
		10/11/90	5.87	4
		10/27/92	7.72	5
		9/16/93	6.5	3
		6/22/94	6.5	6
Northen pike	Kalamazoo River	7/71	8.22	1
	Lake Allegan	7/71	13.44	1
		8/76	2.1	2
		7/14/87	3.09	2
Small. bass	Kalamazoo River	8/76	1.5	2
		9/81	2.13	2
		7/85	1.89	2
		0/13/93	4.2	3
	Lake Allegan	7/14/87	5.14	2
		9/16/93	5.8	3
Whitefish, Sucker	Portage Creek	9/81	7.6	2
	Kalamazoo River	7/71	56.89	1
		8/7	4.3	2
		10/13/93	4.6	3
	Lake Allegan	7/71	13.77	1
		8/76	7.4	2
		9/16/93	1.7	3

ppm: Parts per million

Table 4. **Concentrations of PCBs in Waterfowl, Turtles, and Mice Collected Near the Kalamazoo River.**

Species	Date	Maximum Concentration (ppm)	Reference
ducks	8/85	4.8	2
turtles	8-9/93	1.9	3
mice	10/93	0.45	3

ppm:Parts per million

Table 5. Percentage Distribution of Demographic Characteristics of Anglers, by County

Characteristics	Total	County		p-value
		Allegan	Kalamazoo	
NUMBER OF CASES	938	697	241	
Age				
Under 18	11.5	14.4	3.3	<0.01
18-30	36.6	35.5	40.0	
31-45	29.9	27.0	38.3	
46-60	15.3	15.9	13.3	
Over 60	6.6	7.2	5.0	
Education				
Less than high school graduate	28.5	32.2	17.9	<0.01
High school graduate	37.5	36.8	39.6	
Some college	24.3	23.1	27.9	
College graduate	9.6	7.9	14.6	
Employment				
Employed full-time	55.7	53.2	63.1	0.08
Employed part-time	8.1	8.5	7.1	
Self-employed	6.9	7.8	4.1	
Unemployed	19.7	20.5	17.4	
Retired	9.5	10.0	8.3	

Comparisons (Allegan vs. Kalamazoo) between distribution frequencies for categorical variables were assessed by Chi-square test.
Comparisons (Allegan vs. Kalamazoo) between means for continuous variables were assessed by student t-test.

Table 6. Percentage Distribution of Fishing Behaviors and Knowledge of Fishing Advisories, by County

Characteristics	Total	County		p-value
		Allegan	Kalamazoo	
NUMBER OF CASES	938	697	241	
Primary reason for fishing KR/PC:				
Recreation/enjoyment	75.3	71.0	87.6	<0.01
Source of food	2.9	3.9	0.0	<0.01
Recreation and source of food	10.6	10.0	12.5	0.28
Others	13.4	18.2	0.0	<0.01
Frequency of fishing trips last year:				
None	29.4	28.8	31.3	0.14
One time only	4.6	5.5	2.1	
2-5 times	18.4	18.9	17.1	
6 or more times	47.5	46.8	49.6	
Seasonal variation in fishing:				
Spring	63.2	63.8	61.7	0.56
Summer	94.7	94.8	94.6	0.90
Fall	51.4	54.5	42.5	<0.01
Winter	16.0	18.4	9.2	<0.01
Changes in fishing frequency (between year surveyed & previous years):				
Increase	45.9	42.6	55.0	<0.01
Decrease	10.0	9.4	11.7	
Remain about the same	44.1	48.0	33.3	
Species of interest to participants:				
Walleye	15.7	12.7	38.9	<0.01
Suckers	2.6	1.5	11.5	<0.01
Carp	7.0	6.1	13.5	0.05
Bass	39.3	36.9	58.2	<0.01
Pike	13.9	11.1	35.2	<0.01
Panfish	16.7	15.7	25.0	0.09
Catfish	37.6	37.3	39.6	0.74
Bullheads	4.8	3.2	17.3	<0.01
Turtles	2.6	1.2	13.5	<0.01
Concerned about safety of eating KR/PC fish:	63.0	59.9	71.8	<0.01
Aware of fish consumption advisories:	46.2	40.0	63.9	<0.01
Aware of organization issuing advisories:	27.5	23.2	41.6	<0.01
Changes in fishing behavior expected after cleanup up:				
No Change	60.0	60.8	57.7	<0.01
More trips KR & fewer to other river sites	24.0	18.9	39.7	
More trips KR & same to other river sites	15.7	20.0	2.6	
Don't know	0.3	0.3	0.0	
Interested in a follow-up study:	48.9	50.9	43.3	0.40

KR :Kalamazoo River PC: Portage Creek

Table 7. Percentage Distribution of Fish Consumption Characteristics, by County

Characteristics	Total	County		p-value
		Allegan	Kalamazoo	
NUMBER OF CASES	938	697	241	
Participants eating KR/PC fish:	44.3	47.0	34.7	<0.01
Participants eating KR/PC turtles:	11.3	11.0	12.4	0.62
Household members eating KR/PC fish:	39.4	43.0	27.0	<0.01
Household members eating KR/PC turtles:	9.5	8.7	12.2	0.19
Give fish to friends:	17.0	15.8	38.5	<0.01
Catch and release only:	73.5	66.3	97.2	<0.01
Species of fish consumed (participants):				
Walleye	43.5	37.4	72.4	<0.01
Suckers	13.1	6.2	58.8	<0.01
Carp	27.8	22.2	66.7	<0.01
Bass	69.2	64.2	89.7	<0.01
Pike	37.5	27.8	84.6	<0.01
Panfish	63.3	57.2	93.9	<0.01
Catfish	83.6	83.7	83.3	0.97
Bullheads	29.9	19.2	90.9	<0.01
Species of fish consumed (household members):				
Walleye	38.9	33.1	69.2	<0.01
Suckers	9.3	5.2	42.9	<0.01
Carp	22.1	18.3	57.1	<0.01
Bass	60.5	55.5	83.9	<0.01
Pike	32.4	24.4	77.3	<0.01
Panfish	57.5	52.3	88.5	<0.01
Catfish	79.1	79.8	73.7	0.54
Bullheads	25.4	16.3	84.2	<0.01
Frequency of fish consumed (participants):				
Less than once per month	40.7	37.3	59.0	0.09
Approximately once per month	34.3	36.4	23.1	
Approximately once per week	13.7	14.4	10.3	
More than once per week	11.3	12.0	7.7	
Frequency of fish consumed (household members):				
Less than once per month	45.5	42.4	59.3	0.15
Approximately once per month	31.6	33.3	24.1	
Approximately once per week	13.1	13.6	11.1	
More than once per week	9.8	10.7	5.6	
Preserve fish:	31.2	39.7	12.2	<0.01
Species preserved:				
Walleye	32.0	28.1	63.3	0.04
Suckers	8.5	7.9	16.7	0.99
Carp	15.7	15.7	16.7	0.99
Bass	54.5	50.0	91.7	0.01
Pike	21.6	16.3	75.0	<0.01
Panfish	57.0	53.2	91.7	0.01
Catfish	79.2	79.3	77.8	0.99
Bullheads	20.9	16.7	62.5	0.01
Turtles	15.0	11.0	57.1	0.01

KR: Kalamazoo River
PC: Portage Creek

Table 8. The Mean Amount of Fish Consumed and Preserved, by County

Characteristics	Total		County				p-value
			Allegan		Kalamazoo		
	Mean	(SD)	Mean	(SD)	Mean	(SD)	
Mean years of participants eating KR/PC fish:	10.3	(11.4)	10.4	(11.7)	10.1	(10.4)	0.88
Mean fish meals per year:	26.2	(52.0)	27.8	(56.5)	18.7	(19.6)	0.09
Walleye	4.3	(6.0)	4.9	(6.9)	2.9	(2.9)	0.09
Suckers	2.7	(4.)	3.0	(4.3)	2.5	(3.9)	0.80
Carp	4.6	(6.6)	4.7	(7.4)	4.8	(5.7)	0.98
Bass	10.4	(25.8)	12.3	(30.3)	6.1	(9.4)	0.10
Pike	3.6	(4.5)	3.4	(5.1)	3.8	(3.7)	0.79
Panfish	14.5	(25.2)	17.8	(29.1)	6.4	(10.1)	0.01
Catfish	12.9	(27.6)	14.3	(29.4)	4.4	(6.8)	<0.01
Bullheads	7.8	(18.7)	11.5	(25.2)	3.6	(4.1)	0.21
Turtles	4.0	(5.0)	3.0	(3.0)	4.9	(6.3)	0.30
Number of household members eating fish:							
Adults	1.8	(1.4)	1.9	(1.4)	1.3	(1.0)	0.01
Children 5 to 18 years old	1.3	(1.5)	1.3	(1.6)	0.9	(0.4)	0.01
Children under 5 years old	0.4	(.7)	0.3	(.7)	0.9	(0.6)	0.02
Number of household members not eating fish:							
Adults	0.6	(1.0)	0.6	(1.1)	0.8	(0.6)	0.63
Children 5 to 18 years old	0.4	(.8)	0.4	(0.8)	0.4	(0.5)	0.94
Children under 5 years old	0.3	(0.6)	0.2	(0.5)	0.6	(0.9)	0.18
Amount preserved (lbs):							
Walleye	11.0	(15.8)	12.8	(17.2)	3.8	(5.1)	0.22
Suckers	4.3	(6.8)	3.8	(4.0)	5.0	(10.0)	0.81
Carp	12.3	(21.6)	14.5	(22.9)	0.0	(0.0)	0.41
Bass	13.7	(21.2)	14.7	(22.9)	8.1	(3.8)	0.43
Pike	19.3	(25.7)	20.6	(28.7)	14.3	(8.7)	0.67
Panfish	16.0	(22.9)	18.1	(24.9)	7.2	(5.2)	0.01
Catfish	18.9	(17.8)	19.3	(18.1)	10.5	(8.2)	0.34
Bullheads	11.7	(10.6)	13.3	(12.1)	8.4	(6.9)	0.42
Turtles	25.0	(24.1)	18.3	(21.6)	38.3	(27.5)	0.27

KC: Kalamazoo River
PC: Portage Creek

Table 9. Percentage Distribution of Demographic Characteristics, by County, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	n †	Total ‡	County		p-value
			Allegan ‡	Kalamazoo ‡	
N	151		104	47	
Age:					0.93
Under 31	41	36.0	35.0	38.2	
31 - 45	50	43.9	45.0	41.2	
Over 45	23	20.2	20.0	20.6	
Education:					0.02
Less than high school graduate	43	28.5	30.8	23.4	
High school graduate	48	31.8	37.5	19.1	
Some college	38	25.2	20.2	36.2	
College graduate	22	14.6	11.5	21.3	
Race:					0.26
White	129	86.6	84.5	91.3	
All other	20	13.4	15.5	8.7	
Sex:					0.06
Female	37	24.5	28.8	14.9	
Male	114	75.5	71.2	85.1	

†: Participants in sub-groups may not add to 151(total size sample) owing to missing values.
‡: Percentages may not add to 100 owing to rounding.
P-values were determined by Chi-square test.

Table 10. Means/Percentage Distribution of Selected Characteristics, by County, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	n	Total
N		
Anthropometric measures		
Mean height (inches) (Mean±Standard Deviation):	151	68.1 ± 4.1
Mean weight (lbs) (Mean±Standard Deviation):	151	177.0 ± 44.6
Health habits/exposure		
Smoking status (%):		
Currently smoke	77	51.7
Ever smoked	24	16.1
Never smoked	48	32.2
Drinking status (%):		
Presently drink	103	68.7
Former drinker	19	12.7
Total abstainer	28	18.7
Ever exposed to industrial Chemicals (%):		
Yes	84	55.6
No	67	44.4
Ever exposed to farm Chemicals (%):		
Yes	73	48.3
No	78	51.7
Aware of fish consumption advisories (%):		
Yes	35	26.5
No	97	73.5
Weight change occurred past year (%):		
Yes	64	42.7
No	86	57.3
Changes in weight (%):		
Increased	37	59.7
Decreased	13	21.0
Both	12	19.4
Self-considered health status (%):		
Excellent	34	22.7
Good	78	52.0
Fair or Poor	38	25.3
Hospitalized in last 5 years (%):		
Yes	39	25.8
No	112	74.2

Percentages may not add to 100 owing to rounding.
Participants in sub-groups may not add to 151 owing to missing values.

Table 11. Percentage Distribution of 12 Most Frequent Self-Reported Medical Problems, by County, Portage Creek-Kalamazoo River Angler Survey, 1993

Medical Problems	Total	County		p-value
		Allegan	Kalamazoo	
No. of Participants	151	104	47	
Allergies	39.1	49.0	17.0	<0.01
Bronchitis	24.7	26.2	21.3	0.55
Numbness or tingling in arms or legs	21.2	20.2	23.4	0.67
Persistent skin rashes or eruptions	18.5	20.2	14.9	0.50
Rheumatism or arthritis	18.0	20.4	12.8	0.36
Coughing up a lot of phlegm	16.7	21.4	6.4	0.03
Persistent headache (>1/wk)	16.6	21.2	6.4	0.03
Stomach/duodenal ulcer	15.3	17.5	10.6	0.34
Coughing spells	13.9	16.3	8.5	0.31
Hypertension	13.4	16.5	6.5	0.12
Pneumonia	12.6	13.5	10.6	0.80
General and persistent fatigue	11.9	12.5	10.6	0.99

Medical problems refer to which participants ever had.
P - values were determined by Chi - Square test.

Table 12. Mean/Percentage Distribution of Fish Consumption, by County, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	Total	County		p-value
		Allegan	Kalamazoo	
No. of Participants	151	104	47	
Ate KR/PC fish in the past year (%):	49.3	46.5	55.3	0.38 †
Mean years of eating KR/PC fish (years): *	12.2 ± 10.6	11.0 ± 9.6	16.2 ± 12.9	0.07 ‡
Mean consumption of KR/PC fish in past year (lbs): *	8.9 ± 12.9	9.6 ± 13.7	6.0 ± 9.1	0.35 ‡

†: P- value was determined by Chi - Square test.
‡: P - values were determined by Student t - test.
*: Mean ± Standard Deviation.
KR: Kalamazoo River
PC: Portage Creek

Table 13. Percentage Distribution of Fish Consumption Characteristics in the Past Year, by County, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	n	Total	County		p-value
			Allegan	Kalamazoo	
No. of participants who ate fish	75		54	21	
Mean fish consumption: †					0.54
< 6 lbs.	43	61.4	58.9	71.4	
≥ 6 lbs.	27	38.6	41.1	28.6	
Meals of eating KR/PC fish: †					0.24
< 12 meals	42	59.2	55.4	73.3	
≥ 12 meals	29	40.8	44.6	26.7	
Changes in fish consumption (vs. prior years): ‡					0.77
Remained the same	67	61.5	60.0	66.7	
Increased	13	11.9	12.9	8.3	
Decreased	29	26.6	27.1	25.0	

Percentage may not add to 100 owing to rounding.
†: Participants in sub-groups may not add to 75 (persons who ate KR/PC fish in the past year) owing to missing values.
‡: Participants in sub-groups did not add to 151 (the total sample size) owing to missing values.
P-values were determined by Chi-square test.
KR: Kalamazoo River
PC: Portage Creeks

Table 14. Association Between Selected Characteristics and Fish Consumption, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	Ate fish in the past year (%) n	Yes	No	p-value
Age:				0.13
Under 31	41	32.3	40.0	
31 - 45	50	40.3	48.0	
Over 45	23	27.4	12.0	
Education:				0.52
Elementary or some high school	43	28.0	27.4	
High school graduate	48	36.0	28.8	
Some college	38	20.0	30.1	
College graduate	22	16.0	13.7	
Race:				0.03
White	129	79.7	93.1	
All others	20	20.3	6.9	
Sex:				0.06
Female	37	32.0	17.8	
Male	114	68.0	82.2	
Smoking status:				0.09
Currently smoke	77	58.7	43.7	
Ever smoked	24	17.3	15.5	
Never smoked	48	24.0	40.8	
Drinking status:				0.15
Presently drink	103	68.0	68.1	
Former drinker	19	17.3	8.3	
Total abstainer	28	14.7	23.6	
Weight change in the past year:				0.62
Yes	64	40.5	45.2	
No	86	59.5	54.8	
Aware of fish advisories:				0.55
Yes	97	72.1	77.0	
No	35	27.9	23.0	

Percentage may not add to 100 owing to rounding.
Participants in sub-groups may not add to 151 owing to missing values.
P - values were determined by Chi - Square test.

Table 15. Association Between Selected Characteristics and Fish Consumption, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	n	Fish meals in the past year (%) < 12 meals	Fish meals in the past year (%) ≥ 12 meals	p-value
Age:				0.40
Under 31	20	36.4	24.0	
31 - 45	25	42.4	40.0	
Over 45	17	21.2	36.0	
Education:				0.14
Elementary or some high school	21	28.6	34.5	
High school graduate	27	28.6	48.3	
Some college	15	23.8	10.3	
College graduate	12	19.0	6.9	
Race:				0.83
White	59	78.0	75.9	
All others	15	22.0	24.1	
Sex:				0.83
Female	24	33.3	31.0	
Male	51	66.7	69.0	
Smoking status:				0.44
Currently smoke	44	54.8	69.0	
Ever smoked	13	19.0	10.3	
Never smoked	18	26.2	20.7	
Drinking status:				0.57
Presently drink	51	71.4	62.1	
Former drinker	13	14.3	24.1	
Total abstainer	11	14.3	13.8	
Weight change in the past year:				0.09
Yes	30	28.6	51.7	
No	44	71.4	48.3	
Aware of fish advisories:				0.09
Yes	49	81.6	60.7	
No	19	18.4	39.3	

Percentage may not add to 100 owing to rounding.
Participants in subgroups may not add to 75 (persons who ate fish in the past year) owing to missing values.
P - values were determined by Chi - Square test.

Table 16. Association Between Selected Characteristics and Fish Consumption, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	Years of eating fish		p-value
	n	Mean ± SD	
Age:			0.01
Under 31	20	8.0 ± 5.4	
31 - 45	25	10.1 ± 9.3	
Over 45	17	18.0 ± 13.8	
Education:			0.72
Elementary or some high school	21	11.3 ± 10.6	
High school graduate	27	13.3 ± 9.5	
Some college	15	13.3 ± 13.3	
College graduate	12	9.3 ± 9.1	
Race:			0.74
White	59	12.0 ± 10.1	
All others	15	13.0 ± 12.8	
Sex:			0.70
Female	24	11.5 ± 9.6	
Male	51	12.5 ± 11.0	
Smoking status:			0.17
Currently smoke	44	13.9 ± 10.8	
Ever smoked	13	8.5 ± 11.8	
Never smoked	18	9.8 ± 8.6	
Drinking status:			0.06
Presently drink	51	13.4 ± 11.1	
Former drinker	13	13.8 ± 10.3	
Total abstainer	11	5.5 ± 4.3	
Weight change in the past year:			0.46
Yes	30	11.1± 10.9	
No	44	12.9± 10.3	
Aware of fish advisories:			0.07
Yes	49	14.2 ± 11.1	
No	19	9.1 ± 8.9	

SD: standard deviation.
Participants in sub-groups may not add to 75 (persons who ate KR/PC fish in the past year) owing to missing values.
P - values were determined by one-way analysis of variance (ANOVA).

Table 17. Association Between Selected Characteristics and Fish Consumption, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	Fish consumption (lbs.) in past year		p-value
	n	Mean ± SD	
Age:			0.38
Under 31	20	6.1 ± 8.9	
31 - 45	25	10.9 ± 14.3	
Over 45	17	12.4 ± 17.6	
Education:			0.22
Elementary or some high school	21	12.2 ± 18.0	
High school graduate	27	10.1 ± 11.5	
Some college	15	4.5 ± 5.7	
College graduate	12	4.0 ± 6.0	
Race:			0.83
White	59	9.2 ± 13.6	
All others	15	8.4 ± 11.5	
Sex:			0.18
Female	24	5.9 ± 8.6	
Male	51	10.4 ± 14.5	
Smoking status:			0.26
Currently smoke	44	10.9 ± 13.9	
Ever smoked	13	6.9 ± 10.8	
Never smoked	18	5.0 ± 10.9	
Drinking status:			0.03
Presently drink	51	6.6 ± 10.3	
Former drinker	13	17.4 ± 18.1	
Total abstainer	11	9.9 ± 14.0	
Weight change in the past year:			0.03
Yes	30	13.1 ± 17.6	
No	44	6.3 ± 8.1	
Aware of fish advisories:			0.85
Yes	49	9.7 ± 13.6	
No	19	8.9 ± 12.8	

SD: standard deviation.
Participants in sub-groups may not add to 75 (persons who ate KR/PC fish in the past year) owing to missing values.
P - values were determined by one-way analysis of variance (ANOVA).

Table 18. Association Between Selected Characteristics and Fish Consumption, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	Fish consumption in the past year (%) n	< 6 lbs.	≥ 6 lbs.	p-value
Age:				0.58
Under 31	20	36.4	24.0	
31 - 45	25	39.4	44.0	
Over 45	17	24.2	32.0	
Education:				0.12
Elementary or some high school	21	27.9	37.0	
High school graduate	27	30.2	48.1	
Some college	15	23.3	7.4	
college graduate	12	18.6	7.4	
Race:				0.88
White	59	76.2	77.8	
All others	15	23.8	22.2	
Sex:				0.13
Female	24	39.5	22.2	
Male	51	60.5	77.8	
Smoking status:				0.08
Currently smoke	44	51.2	77.8	
Ever smoked	13	20.9	7.4	
Never smoked	18	27.9	14.8	
Drinking status:				0.28
Presently drink	51	74.4	59.3	
Former drinker	13	11.6	25.9	
Total abstainer	11	14.0	14.8	
Weight change in the past year:				0.42
Yes	30	34.9	44.4	
No	44	65.1	55.6	
Aware of fish advisories:				0.79
Yes	49	71.1	74.1	
No	19	28.9	25.9	

Percentage may not add to 100 owing to rounding.
Participants in sub-groups may not add to 75 (persons who ate KR/PC fish in the past year) owing to missing values.
P - values were determined by Chi - Square test.

Table 19. Blood Contaminants (ppb), by County, Portage Creek-Kalamazoo River Angler Survey, *1993*

Blood Contaminants	GM	SEM	Median	Range Minimum	Range Maximum	n*
Total:						
PCB Total	1.55	3.22	1.40	.10	73.00	144
DDE	2.31	2.39	2.20	.40	26.70	144
Mercury	3.16	1.49	2.80	2.00	9.60	32
Allegan:						
PCB Total	1.57	3.29	1.40	.10	73.00	99
DDE	2.29	2.59	2.20	.40	26.70	97
Mercury	3.28	1.54	2.80	2.00	9.60	21
Kalamazoo:						
PCB Total	1.55	3.13	1.50	.20	31.20	45
DDE	2.34	1.97	2.00	.50	10.90	47
Mercury	2.97	1.40	2.50	2.00	5.30	11

PCB total and DDE contaminants are from serum sample; Mercury contaminant is from whole blood sample.
GM: Geometric Mean; SEM: Standard Error Mean.
*: Sample size (n) refers to participants with detectable contaminant levels.

Table 20. Blood Contaminants (ppb), by Age Groups, Portage Creek-Kalamazoo River Angler Survey, 1993

Blood Contaminants	GM	SEM	Median	Range		n*	p-value
				Minimum	Maximum		
PCB total:							<0.01
age: under 31	0.90	3.29	0.80	0.10	9.30	39	
31-45	1.65	3.00	1.55	0.10	72.97	48	
over 45	3.35	2.83	1.94	0.40	31.19	22	
DDE							<0.01
age: under 31	1.31	1.89	1.30	0.50	6.89	39	
31-45	2.66	2.18	2.80	0.50	22.42	49	
over 45	4.44	2.09	4.71	1.20	13.60	22	
Mercury:							0.99
age: under 31	3.22	1.90	2.29	1.99	9.58	6	
31-45	3.35	1.28	3.29	2.51	5.31	7	
over 45	3.29	1.62	2.80	1.99	7.32	7	

PCB total and DDE contaminants are from serum sample; Mercury contaminant is from whole blood sample.
P-values were determined by one-way analysis of variance (ANOVA).
GM: Geometric Mean; SEM: Standard Error Mean.
*: Sample size (n) refers to participants with detectable contaminant levels.

Table 21. Blood Contaminants (ppb), Fisheaters Vs. Non-Fisheaters, Portage Creek-Kalamazoo River Angler Survey, 1993

Blood Contaminants	Range						
	GM	SEM	Median	Minimum	Maximum	n*	p-value
PCB total:							< 0.01
Fisheaters	2.10	3.32	1.95	0.10	73.00	72	
Non-fisheaters	1.11	2.89	1.10	0.10	37.80	69	
DDE:							0.01
Fisheaters	2.75	2.48	2.85	0.50	26.70	72	
Non-fisheaters	1.93	2.18	1.90	0.40	24.30	70	
Mercury:							0.86
Fisheaters	3.13	1.54	2.60	2.00	9.60	21	
Non-fisheaters	3.22	1.40	2.90	2.10	6.10	11	

PCB total and DDE contaminants are from serum sample; Mercury contaminant is from whole blood sample.
P-values were determined by student t-test.
GM: Geometric Mean; SEM: Standard Error Mean.
*: Sample size (n) refers to participants with detectable contaminant levels.

Table 22. Association Between Selected Characteristics and Blood Contaminants, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	PCB			Mercury			DDE		
	n	≥ Median: 1.40 ppb (%)	p	n	≥ Median: 2.80 ppb (%)	p	n	≥ Median: 2.20 ppb (%)	p
Age:			<0.01			NC			<0.01
Under 31	39	25.6		6	33.3		39	20.5	
31 - 45	48	64.6		7	71.4		49	67.3	
Over 45	22	81.8		7	42.9		22	77.3	
Education:			0.09			NC			0.28
Elementary or some high school	41	43.9		7	28.6		37	43.2	
High school graduate	45	66.7		10	60.0		48	62.5	
Some college	36	44.4		6	33.3		37	45.9	
College graduate	22	63.6		9	44.4		22	54.5	
Race:			0.30			0.99			<0.01
White	122	52.5		26	42.3		122	46.7	
All others	20	65.0		6	50.0		20	85.0	
Sex:			0.18			0.61			0.04
Female	36	63.9		4	25.0		36	66.7	
Male	108	50.9		28	46.4		108	47.2	
Weight change in the past year:			0.28			0.70			0.73
Yes	59	49.2		8	50.0		58	50.0	
No	84	58.3		24	41.7		85	52.9	

P-values were determined by chi-square test.
NC: P-values not calculated because of the small number of cases.

Table 23. Association Between Fish Consumption and Blood Contaminants (Log Transformed), Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	PCB			Mercury			DDE		
	n	≥ Median: 1.40 ppb (%)	p	n	≥ Median: 2.80 ppb (%)	p	n	≥ Median: 2.20 ppb (%)	p
Ate fish in past year:			<0.01			0.46			0.02
Yes	72	68.1		21	38.1		72	62.5	
No	69	37.7		11	54.5		70	41.4	
Fish meals in past year:			0.59			0.05			0.20
< 12 fish meals	41	65.9		15	26.7		40	57.5	
≥ 12 fish meals	28	75.0		6	83.3		27	74.1	
Fish consumption (lbs) in past year:			0.86			0.36			0.60
< 6 lbs.	41	68.3		12	33.3		40	60.0	
≥ 6 lbs.	27	70.4		8	62.5		26	69.2	

P - values were determined by Chi - Square test.

Table 24. **Factors of Fish Consumption Associated with Blood Contaminants, Portage Creek-Kalamazoo River Angler Survey, 1993 (Unadjusted Odds Ratios)**

Variables	PCB	DDE
Ate fish in the past year:	*p<0.01*	*p<0.01*
No	1.00	1.00
Yes	3.52	2.36
Fish meals in past year:	*p=0.41*	*p=0.16*
< 12 meals	1.00	1.00
≥ 12 meals	1.56	2.11
Fish consumption (lbs) in past year:	*p=0.86*	*p=0.44*
< 6 lbs.	1.00	1.00
≥ 6 lbs.	1.10	1.50

Odds ratios were estimated by simple logistic regression model.

Table 25. **Selected Factors Associated with Blood Contaminants, Portage Creek-Kalamazoo River Angler Survey, 1993 (Unadjusted Odds Ratios)**

Variables	PCB	DDE
Age	*p<0.01*	*p<0.01*
Under 30	1.00	1.00
31 - 45	5.29	7.99
Over 45	13.05	13.17
Education:	*p=0.08*	*p=0.27*
Elementary or some high school	1.00	1.00
High school graduate	2.56	2.18
Some college	1.02	1.11
College graduate	2.24	1.58
Race:	*p=0.29*	*p<0.01*
White	1.00	1.00
All others	1.68	6.46
Sex:	*p=0.17*	*p=0.04*
Male	1.00	1.00
Female	1.70	2.24
Aware of fish consumption advisories	*p=0.18*	*p=0.16*
Yes	0.58	0.48
No	1.00	1.00
Smoke status:	*p=0.24*	*p=0.28*
Currently smoke	1.88	1.77
Ever smoked	1.32	1.15
Never smoked	1.00	1.00
Drinking status:	*p=0.08*	*p=0.22*
Presently drink	2.51	1.18
Former drinker	3.24	2.83
Total abstainer	1.00	1.00
Self-considered health status	*p=0.39*	*p=0.69*
Excellent	1.00	1.00
Good	0.55	0.74
Fair or poor	0.61	0.97

Odds ratios were estimated by simple logistic regression model.
PCB: Polychlorinated Biphenyls

Table 26. **Adjusted Odds Ratios of Log Transformed PCB Contaminant Level ≥1.40 ppb, by Selected Characteristics, Portage Creek-Kalamazoo River Angler Survey, 1993**

Variable	B	S.E	P-value	Odds Ratio
Age:			<0.01	
31-45	2.72	0.86	<0.01	15.25
Over 45	4.34	1.19	<0.01	76.40
Education:			0.41	
High school graduation	0.65	0.88	0.46	1.91
Some college	0.32	0.97	0.74	1.37
College graduation	1.93	1.23	0.12	6.90
Race: All others	2.08	0.99	0.04	8.03
Sex: Male	-1.16	0.77	0.13	0.31
Aware of fish consumption advisories: No	0.08	0.71	0.91	1.08
Smoking status:			<0.01	
Currently smoke	1.19	0.94	0.21	3.28
Ever smoked	-0.77	0.91	0.40	0.46
Drinking status:			<0.01	
Presently drink	0.47	1.04	0.65	1.60
Former drinker	1.51	1.16	0.19	4.54
Self-considered health status			0.02	
Good	-2.98	1.12	0.01	0.05
Fair or Poor	-3.58	1.28	0.01	0.03
Ate fish in the past year: Yes	0.53	0.64	0.41	1.70

Appendix G shows the coding.
P-values were estimated by multiple logistic regression model. The model included age, education, race, sex, smoking and drinking exposure, self-considered health status, and fish-eating status in the past year.
B: Beta coefficient
S.E.: Standard Error of the beta

Table 27. **Adjusted Odds Ratios of Log Transformed DDE Contaminant level ≥2.20 ppb by Selected Characteristics, Portage Creek-Kalamazoo River Angler Survey, 1993**

Variable	B	S.E	P-value	Odds Ratio
Age:			<0.01	
31-45	2.11	0.75	<0.01	8.27
Over 45	2.91	0.90	<0.01	18.43
Education:			0.96	
High school graduation	0.21	0.83	0.80	1.23
Some college	0.30	0.94	0.75	1.34
College graduation	0.57	1.08	0.60	1.76
Race: All others	3.63	1.33	0.01	37.55
Sex: Male	-1.06	0.67	0.11	0.35
Aware of fish consumption advisories: No	-0.14	0.69	0.84	0.87
Smoking status:			0.20	
Currently smoke	0.76	0.88	0.38	2.14
Ever smoked	-0.78	0.85	0.36	0.46
Drinking status:			0.71	
Presently drink	0.03	1.04	0.97	1.03
Former drinker	0.70	1.19	0.56	2.00
Self-considered health status			0.35	
Good	-1.21	0.84	0.15	0.30
Fair or Poor	-0.98	0.95	0.30	0.37
Ate fish in the past year: Yes	-0.16	0.60	0.79	0.85

Appendix G shows the coding.
B: regression coefficient; S.E.: Standard Error of regression coefficient.
P-values were estimated by multiple logistic regression model. The model included age, education, race, sex, smoking and drinking exposure, self-considered health status and fish-eating status in the past year.

Appendix A

Division of Health Risk Assessment
Michigan Department of Public Health

Allied Paper, Inc./Portage Creek/Kalamazoo River Angler Survey
Interviewer Instructions for Basic Survey

The interviewer needs to place an ID number at the top of each page at the time of interview. This insures our ability to reassemble the appropriate pages in the event interview packets are broken apart. The ID number should consist of the following:

0001A1
0001K1

The four digits allow for sequentially identifying the interview. The alpha designation is "A" for Allegan County interview team or "K" for Kalamazoo interview team. The numeric designation is for the individual in the county's team. Individual interviewers need to keep the same identification number. The interviewer should note the location date and time at the top of the form.

The interviewer must initiate the contact with the angler (prospective interviewee). Following is a suggested format:

Interviewer: Hello! My name is _____. I am employed by the Allegan County Health Department (Kalamazoo County Human Services Department) to conduct interviews of persons fishing stretches of the Kalamazoo River from the Morrow Pond Dam downstream to the Allegan Dam; and Portage Creek from Cork Street downstream to the Kalamazoo River. Have you been interviewed by anyone while fishing on any of these waters? (If answer is "no," proceed). The interview should only take 10-15 minutes. We are interested in obtaining information on numbers of anglers using these waters and their fish consumption patterns. My I interview you?

Question No. 1. Read it as printed with the exception of only identifying the river or the creek, not both.

Question No. 2. Read it as printed.

Question No. 3. Read it as printed. For subparts 1 or 2 you may have to help the interviewee in arriving at a percentage.

Question No. 4. Read it as printed. Be sure to cover all seasons. Put a + or - as appropriate for each season.

Question No. 5. Read it as printed. Check as appropriate for the interviewee and household member. A "yes" answer for either or both leads to 5a. If no fish are consumed in this household, go to Question No. 10.

Question No. 5a.	Read it as printed. Enter answer.
Question No. 6.	Read it as printed. Read the list of fish and check the species eaten. Be sure to check each species eaten and enter the number of meals eaten by the interviewee.
Question No. 7.	Read it as printed. Read the list of fish and check the one(s) indicated by the interviewee.
Question No. 8.	Read it as printed. Be sure to read the options and check the appropriate column for the interviewee and/or household member.
Question No. 9.	Read it as printed. Be sure to read the options. The same instructions apply to 9a.
Question No. 10.	Read it as printed. Check appropriate answer. For 10a, read the list of fish and check the appropriate species and enter amount as indicated.
Question No. 11.	Read it as printed. Check appropriate answer.
Question No. 12.	Read it as printed. If answer is "yes" ask for which species the interviewee believes the advisory applies. 12a. Only ask if answer to 12 is "yes." If answer to 12a is "yes," ask for the name(s) of the organization(s) the interviewee believes issued the advisory. Let the interviewee tell you.
Question No. 13.	Read the whole descriptive statement and follow with the question on clean up. Read all of the options, so the interviewee can respond with complete knowledge of the total question.
Question No. 14.	Read it as printed. If interviewee hesitates, read age ranges and check appropriate answer.
Question No. 15.	Read it as printed and read the options as printed. Check appropriate answer.
Question No. 16.	Read it as printed and read the options as printed. Check the appropriate answer.
Question No. 17.	Read "a" question as is. Obtain the interviewee's name, address and phone number if they answer "yes." If the answer is "no" just try to obtain what they are willing to share as to the locations indicated.
Question No. 18.	Read it as printed. Be sure to obtain correct spelling of name and address. If the interviewee does not have a telephone, ask what is the best way to contact him/her for follow-up. Write answers as indicated.

Division of Health Risk Assessment
Michigan Department of Public Health

County_____

Interviewer_____

Date_____

Allied Paper Inc./Portage Creek/Kalamazoo River Angler Survey

This form is designed to give us the information about anglers who did not wish to be interviewed. The interviewer should fill it out to the best of their ability. It should be turned in daily.

Non-Participants Observations by Interviewer

1. Age: _____< 15 _____16-25 _____25-40 _____>45

   Race: _____Caucasian _____Afro American _____Hispanic

   _____American Indian _____Asian _____Other

   Sex: _____Male _____Female _____?

2. Age: _____< 15 _____16-25 _____25-40 _____>45

   Race: _____Caucasian _____Afro American _____Hispanic

   _____American Indian _____Asian _____Other

   Sex: _____Male _____Female _____?

3. Age: _____< 15 _____16-25 _____25-40 _____>45

   Race: _____Caucasian _____Afro American _____Hispanic

   _____American Indian _____Asian _____Other

   Sex: _____Male _____Female _____?

Appendix B

Draft 4-26-94

ID Number ____ ____ ____ ____ ____ ____

LOCATION_____

DATE_____ TIME_____

MICHIGAN DEPARTMENT OF PUBLIC HEALTH
ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER
ANGLER SURVEY
BASIC QUESTIONNAIRE

Interviewer inform the angler of the following information (use map if necessary):

We are only interested in information pertaining to portions of the Kalamazoo River downstream from the Morrow Pond Dam to the Allegan Dam; and Portage Creek downstream from Cork Street to the Kalamazoo River.

1. What is your primary reason for fishing the Kalamazoo River/Portage Creek?

_____ 1. Recreation/enjoyment
_____ 2. Source of food
_____ 3. Recreation and source of food
_____ 4. Other (please explain) _____

2. How many times did you fish the Kalamazoo River or Portage Creek last calendar year?

_____ 1. None
_____ 2. One time only
_____ 3. 2-5 times
_____ 4. 6 or more times

3. Do you think your fishing this year on the Kalamazoo River or Portage Creek will:

_____ 1. Increase _____ % more trips
_____ 2. Decrease _____ % fewer trips
_____ 3. Remain about the same

4. What seasons of the year do you fish the Kalamazoo River or Portage Creek. List the season(s).

_____ 1. Spring
_____ 2. Summer
_____ 3. Fall
_____ 4. Winter

Authority: Public Act 368 of 1978; Completion: Voluntary

5. Do you or other members of your household eat the fish or snapping turtles you catch from the Kalamazoo River or Portage Creek?

Interviewee		Household member		
Fish	S. Turtle	Fish	S. Turtle	
_____	_____	_____	_____	1. Yes (continue)
_____	_____	_____	_____	2. No (go to question 10)
_____				3. I give all the fish to friends (go to Quest. 10)
_____				4. Catch and release only (go to Question 10)

5a. How many years have you been eating fish you caught from the Kalamazoo River or Portage Creek?_____

6. What species of fish do you or others in your household eat from the Kalamazoo River or Portage Creek?

Interviewee	Household member		6a. Approximate number of meals per year?
_____	_____	1. Walleye	_____meals
_____	_____	2. Suckers	_____meals
_____	_____	3. Carp	_____meals
_____	_____	4. Bass (small mouth and large mouth)	_____meals
_____	_____	5. Pike	_____meals
_____	_____	6. Panfish (perch, crappie, bluegill, sunfish)	_____meals
_____	_____	7. Catfish	_____meals
_____	_____	8. Bullheads	_____meals
_____	_____	9. Snapping Turtles	_____meals
_____	_____	10. Other _____	

7. What species of fish do you "target," or fish for?

_____ 1. Walleye
_____ 2. Suckers
_____ 3. Carp
_____ 4. Bass (small mouth and large mouth)
_____ 5. Pike
_____ 6. Panfish (perch, crappie, bluegill, sunfish)
_____ 7. Catfish
_____ 8. Bullheads
_____ 9. Snapping Turtles
_____ 10. Other

8. How often are the fish you catch in the Kalamazoo River or Portage Creek eaten by you or others in your household?

Interviewee	Household member	
_____	_____	1. Less than once per month
_____	_____	2. Approximately once per month
_____	_____	3. Approximately once per week
_____	_____	4. More than once per week

9. Other than yourself, how many persons in your household eat the fish you catch from the Kalamazoo River or Portage Creek?

_____ 1. Adults
_____ 2. Children 5 to 18 years old
_____ 3. Children under 5 years old

9a. How many persons in your household do not eat the fish you catch from the Kalamazoo River or Portage Creek?

_____ 1. Adults
_____ 2. Children 5 to 18 years old
_____ 3. Children under 5 years old

10. Do you freeze, smoke, or can the fish you catch in the Kalamazoo River or Portage Creek for later use?

_____ 1. Yes
_____ 2. No

10a. If yes, what species do you freeze, smoke or can?

Interviewee		10b. Approximately how many pounds per year?
_____	1. Walleye	_____lbs.
_____	2. Suckers	_____lbs.
_____	3. Carp	_____lbs.
_____	4. Bass (small mouth and large mouth)	_____lbs.
_____	5. Pike	_____lbs.
_____	6. Panfish (perch, crappie, bluegill, sunfish)	_____lbs.
_____	7. Catfish	_____lbs.
_____	8. Bullheads	_____lbs.
_____	9. Snapping Turtle	_____lbs.
_____	10. Other	

11. Do you have any concerns about the safety of eating fish from the Kalamazoo River or Portage Creek?

_____ 1. Yes
_____ 2. No

12. Do you know if there is a fish consumption advisory about eating certain species of fish in this stretch of the Kalamazoo River and for Portage Creek?

_____ 1. Yes - For which species _____?
_____ 2. No

12a. If yes - Do you know the organization responsible for issuing such advisories?

_____ 1. Yes - Name of organization(s) _____
_____ 2. No

13. There are fish consumption advisories which recommend limited consumption of all fish species on this stretch of the Kalamazoo River and portion of Portage Creek. If pollutants in the river and creek are cleaned up sufficiently for fish consumption advisories to be removed on all species, would you:

_____ 1. Not change your fishing trip behavior
_____ 2. Take more trips to this stretch of the Kalamazoo River and fewer to other river sites.

_____ a. How many more trips to this stretch of the Kalamazoo River?
_____ b. How many fewer trips to other stretches of the Kalamazoo River? (above Morrow Pond Dam or below Allegan Dam?)

_____ 3. Take more trips to this stretch of the Kalamazoo River and the same number of trips to other river sites?

_____ a. How many more trips to this Kalamazoo River stretch?

_____ 4. Don't know

14. What is your age?

_____ 1. Under 18
_____ 2. 18-30
_____ 3. 31-45
_____ 4. 46-60
_____ 5. Over 60

15. Which of the following best describes your education?

_____ 1. Less than high school graduate
_____ 2. High school graduate
_____ 3. Some college
_____ 4. College graduate

16. Are you currently?

_____ 1. Employed full-time
_____ 2. Employed part-time
_____ 3. Self-employed
_____ 4. Unemployed
_____ 5. Retired

17a. Are you willing to be reinterviewed at a later date as part of our quality control on this survey?
____Yes ____No If "NO" go to 17b.

17b. Residence:

If "YES" obtain following:
Name_____ State_____

Address_____ County_____

City/State/Zip_____ City_____

Phone # _____

18. Would you be interested in a follow-up study which might involve a health questionnaire survey and the furnishing of a blood specimen for chemical analyses of PCB and Mercury? (The blood will be obtained by venipuncture and it will require approximately 15-20 ml of blood or 2-3 tablespoons)

_____ 1. Yes
_____ 2. No

IF YES:
Name_____

Street_____

City_____ State _____ Zip_____

Telephone # _____

Appendix C

MICHIGAN DEPARTMENT OF PUBLIC HEALTH
BUREAU OF ENVIRONMENTAL AND OCCUPATIONAL HEALTH
DIVISION OF HEALTH RISK ASSESSMENT

Kalamazoo River/Portage Creek Angler Survey
Health Assessment

Date ___/___/___

I.D. NUMBER ___/___/___

WITH RESPECT TO THIS STUDY AND YOUR PARTICIPATION, WE WISH TO FOCUS ON FISH FROM THE KALAMAZOO RIVER AND PORTAGE CREEK.

Q 1 BESIDES THE COMMERCIALLY CAUGHT FISH THAT IS SOLD IN STORES AND RESTAURANTS, HAVE YOU EATEN FISH IN THE PAST TWELVE MONTHS THAT WAS CAUGHT BY YOURSELF OR ANOTHER SPORTS FISHERMAN FROM KALAMAZOO RIVER AND PORTAGE CREEK. ____

yes = 1
no = 2
dk = 9

Q 2 OVER THE PERIOD OF THE LAST FIVE YEARS, HAS YOUR CONSUMPTION OF FISH FROM THE KALAMAZOO RIVER AND/OR PORTAGE CREEK REMAINED THE SAME, INCREASED, OR DECREASED? ____

remained the same = 1
increased = 2
decreased = 3
dk = 9
na = 8

if Q 1 = "no or DK", and Q 2 = "remained the same, DK or NA" go to Q 11

Q 3 WHY HAS YOUR FISH CONSUMPTION _____? ____ ____
(response from Q 2) ____ ____
(Specify as many as may apply) ____ ____
____ ____

MORE	LESS
01=fish/catch more	21=fish/catch less
02=cooked different/enjoyed more	22=don't like
03=dieting	23=no longer dieting
04=no longer worried about toxins	24=concerned about toxins
05=price of other food	25=price of other food
06=given more fish	26=given less fish
07=because of this study	27=alternative food sources
08=health reasons	28=health reasons
09=change in family membership	29=change in family membership
10=no reason given	30=no reason given
15=other_____	35=other_____
99=DK	99=DK
99=NA	88=NA

HRA 22(8-94) Public Act 368 of 1978, completion: voluntary

I.D. NUMBER ____/____/____

Q 4 WHEN YOU EAT FISH FROM KALAMAZOO AND PORTAGE CREEK, WHAT KIND OF FISH DO YOU EAT MOST OFTEN ____ most

Q 4a IF THERE IS ANOTHER FISH FROM KALAMAZOO AND PORTAGE CREEK THAT YOU EAT FREQUENTLY, WHAT KIND IS IT? ____

walleye = 1
suckers = 2
carp = 3
bass(smallmouth & largemouth = 4
pike = 5
panfish (perch, crappie, bluegill, sunfish) = 6
catfish = 7
bullheads = 8
snapping turtles = 9
_____other = 10

Q 5 HOW MANY YEARS HAVE YOU BEEN EATING FISH FROM KALAMAZOO RIVER OR PORTAGE CREEK? ____ ____

number of years = 1-70
more than 70 years = 76
less than 1 year = 77
DK = 99
NA = 88

I WOULD NOW LIKE TO ASK YOU HOW MANY TIMES YOU HAVE EATEN SPORT-CAUGHT FISH CAUGHT IN KALAMAZOO AND PORTAGE CREEK IN THE LAST TWELVE MONTHS. WE WILL GO MONTH-BY-MONTH.

Q 6 IN WHICH MONTH(S) DID YOU EAT THE MOST FISH AND HOW MANY FISH MEALS DID YOU EAT EACH MONTH?

Ask for remaining months:

	meals/ month
JAN	____ ____
FEB	____ ____
MAR	____ ____
APR	____ ____
MAY	____ ____
JUN	____ ____
JUL	____ ____
AUG	____ ____
SEPT	____ ____
OCT	____ ____
NOV	____ ____
DEC	____ ____

I.D. NUMBER ____/____/____

Q 7 THIS MODEL OF FISH SHOWS A 4 OUNCE PORTION OF FISH ON A NINE INCH DINNER PLATE. WHAT IS YOUR USUAL SIZE SERVING COMPARED TO THE PORTION IN THIS MODEL?

_____

1/4 of 4 ozs = 1	2-1/2 * 4 ozs = 8
1/3 of 4 ozs = 2	3 * 4 ozs = 9
1/2 of 4 ozs = 3	3-1/2 * 4 ozs = 10
3/4 of 4 ozs = 4	4 * 4 ozs = 11
1 * 4 ozs = 5	more than 4 * 4 ozs = 12
1-1/2 * 4 ozs = 6	DK = 99
2 * 4 ozs = 7	NA = 88

Q 8 HOW DO YOU CLEAN OR PREPARE THESE FISH PRIOR TO COOKING?

Use following choices:
Always = 1
Usually = 2
Sometimes = 3
Rarely = 4
Never = 5
Don't Know = 6

Filet _____
Skin _____
Trim belly flap _____
Trim dorsal and lateral fatty area _____
Scale, remove heads and guts _____
Other (describe) _____

Q 9 WHEN YOU EAT SPORT-CAUGHT FISH, HOW IS IT MOST OFTEN COOKED? _____

Broiled = 1
Baked = 2
Pan fried = 3
Deep fried = 4
_____ others = 5

Q 9a IF THERE IS ANOTHER USUAL METHOD USED TO COOK THE SPORT-CAUGHT FISH YOU EAT, WHAT IS IT? _____

(question 9 and 9a)

Q 9b DO YOU EAT SPORT CAUGHT FISH FROM OTHER WATERS? Yes = 1 No = 2

If yes, what are the other waters? _____

_____

(List waters & Code 1 = Great Lakes and connecting waters, 2 = Inland lakes and streams)

Q 10 IN THE LAST 5 YEARS, HAVE YOU HEARD OR READ FISH ADVISORY INFORMATION PROVIDED BY THE MICHIGAN DEPARTMENT OF PUBLIC HEALTH?

Yes = 1
no = 2
Dk = 9
NA = 8

I.D. NUMBER ____/____/____

WE HAVE NOW COMPLETED ALL OF THE QUESTIONS ABOUT FISH CONSUMPTION. THE FOLLOWING QUESTIONS ARE ASKED TO LEARN MORE ABOUT THE CHARACTERISTICS OF THE STUDY PARTICIPANTS WE ARE INTERVIEWING.

Q 11 WHAT IS THE HIGHEST GRADE OR YEAR YOU HAVE COMPLETED IN SCHOOL?

____

grade 1-8 (elementary school only) = 1
grade 9-11 (some high school) = 2
grade 12 (high school graduate) = 3
grade 13-15 (some college) = 4
grade 16+ (college graduate or more) = 5
DK = 9
NA = 8

Q 12 TO THE BEST OF YOUR KNOWLEDGE, HAVE YOU EVER BEEN SIGNIFICANTLY EXPOSED TO ANY OF THE FOLLOWING MATERIAL AND, IF YOU WERE EXPOSED, WAS THAT EXPOSURE DURING THE PAST YEAR?

	yes ever	yes year	no
Hydraulic oils	_____	_____	___
Capacitors or transformers	_____	_____	___
Electrical equipment	_____	_____	___
Heat transfer chemicals	_____	_____	___
Fungicides (specify brand)	_____	_____	___
Herbicides _____	_____	_____	___
Insecticides _____	_____	_____	___
Other pesticides _____	_____	_____	___
Lead	_____	_____	___
Mercury	_____	_____	___
Other Chemicals _____	_____	_____	___

(Interviewer Information: Heat transfer chemicals may be PCB, phosphates, glycols and oils)

(ever) yes = 1
(past year) yes = 2
no = 3
DK = 9
NA = 8

Q 13 DO YOU SMOKE AT LEAST 1 CIGARETTE, PIPE BOWL OF TOBACCO OR CIGAR A DAY FOR A YEAR OR MORE?

____

Yes = 1
No = 2
DK = 9
NA = 8

if "yes" go to Q 15

I.D. NUMBER ____/____/____

Q 13a HAVE YOU EVER SMOKED AT LEAST 1 CIGARETTE, PIPE BOWL OF TOBACCO OR CIGAR A DAY FOR A YEAR OR MORE? ____

Yes = 1
No = 2
DK = 9
NA = 8

if "no" go to Q 17

Q 14 HOW OLD WERE YOU WHEN YOU LAST SMOKED?
(years old) ____ ____

Q 15 HOW OLD WERE YOU WHEN YOU FIRST SMOKED?
(years old) ____ ____

Q 16 ON THE AVERAGE, HOW MANY (CIGARETTES, PIPE BOWLS OF TOBACCO OR CIGARS) A DAY DO (DID) YOU SMOKE?
(1 pack = 20 cigarettes)

Cigarettes ____ ____
Pipe bowls ____ ____
Cigars ____ ____

number of smokes per day = 1-60
more than 60 = 61
DK = 99
NA = 88

Q 17 DO YOU EVER DRINK ALCOHOLIC BEVERAGES (SUCH AS LIQUOR, WINE OR BEER)? ____

YES, (PRESENTLY DRINKS) = 1
If "no" = 2

HAVE YOU ALWAYS ABSTAINED FROM DRINKING ALCOHOLIC BEVERAGES? ____

No (former user) = 2
yes (total abstainer) = 3
DK = 9
NA = 8

if "yes" (total abstainer) go to Q 22
if "no" (former user) go to Q 18

Q 18 DURING THE (PAST YEAR/YEAR BEFORE YOU QUIT DRINKING) HOW OFTEN DID YOU DRINK ONE OR MORE BEERS? ____

once per month or less = 1
2-3 times per month = 2
once per week = 3
2-3 times per week = 4
4-5 times per week = 5
6-7 times per week = 6
more than once per day = 7
DK = 9
NA = 8

if "once per month or less" go to Q 20

Q 19 HOW MUCH BEER OR ALE WOULD YOU SAY YOU ORDINARILY HAD AT A SITTING (that is from the time you started drinking to the time you stopped)? ____

number of bottles or cans = 1-6
7 or more bottles or cans = 7
DK = 9
none = NA NA = 8

Q 20 HOW MANY GLASSES OF WINE DO YOU HAVE AT A SITTING? ____

number of glasses = 1-6
7 or more glasses = 7
DK = 9
none = NA NA = 8

Q 20a DURING THE (PAST YEAR/YEAR BEFORE YOU QUIT DRINKING), HOW OFTEN DID YOU DRINK ONE OR MORE GLASSES OF WINE? ____

once per month or less = 1
2-3 times per month = 2
once per week = 3
2-3 times per week = 4
4-5 times per week = 5
6-7 times per week = 6
more than once per day = 7
DK = 9
NA = 8

Q 21 HOW MANY DRINKS OF HARD LIQUOR DO YOU HAVE AT A SITTING? ____

number of drinks = 1-6
7 or more drinks = 7
DK = 9
NA = 8

Q 21a DURING THE (PAST YEAR/YEAR BEFORE YOU QUIT DRINKING), HOW OFTEN DID YOU DRINK ONE OR MORE DRINKS OF HARD LIQUOR (WHISKEY, SCOTCH, VODKA, GIN, BRANDIES, LIQUEURS, ETC.) EITHER MIXED OR STRAIGHT? ____

once per month or less = 1
2-3 times per month = 2
once per week = 3
2-3 times per week = 4
4-5 times per week = 5
6-7 times per week = 6
more than once per day = 7
DK = 9
NA = 8

I.D. NUMBER ____/____/____

WE WOULD NOW LIKE TO ASK YOU SOME QUESTIONS ABOUT YOUR CURRENT HEALTH STATUS AND YOUR MEDICAL HISTORY.

Q 22 COMPARED TO PEOPLE YOUR OWN AGE, DO YOU CONSIDER YOUR HEALTH TO BE EXCELLENT, GOOD, FAIR OR POOR? ____

excellent = 1
good = 2
fair = 3
poor = 4
DK = 9

Q 23 WITHIN THE LAST YEAR, HAS THERE BEEN A CHANGE IN YOUR BODY WEIGHT OF MORE THAN 10 POUNDS? ____

yes = 1
no = 2
refused = 3
DK = 9
NA = 8

if Q 23 is "no, refused, or DK" go to Q 26

Q 24 DID YOUR WEIGHT INCREASE, DECREASE OR BOTH? ____

increase = 1
decreased = 2
both = 3
DK = 9
NA = 8

Q 25 BY HOW MANY TOTAL POUNDS DID YOUR WEIGHT CHANGE? ____ ____

number of pounds = 1-86
87 pounds or greater = 87
DK = 99
NA = 88

Q 26 ARE YOU CURRENTLY ON A SUPERVISED DIET? ____

yes = 1
no = 2
DK = 9
NA = 8

if "no" go to Q 28

Q 27 WHAT KIND OF A DIET ARE YOU ON? ____

low calorie = 1
low salt, sodium = 2
low cholesterol = 3
vegetarian = 4
other _____ = 5
DK = 9
NA = 8

I.D. NUMBER ____/____/____

Q 28 DO YOU HAVE ANY ALLERGIES? ____

yes = 1
no = 2
DK = 9
NA = 8

if "no" "NA" "DK" go to Q 29

if "yes" go to Q 28a

Q 28a PLEASE SPECIFY YOUR ALLERGIES.

	YES	NO	DK	
_____ foods	___	___	___	___
_____ pollens	___	___	___	___
_____ drugs or vaccines	___	___	___	___
_____ animal fur	___	___	___	___
_____ other	___	___	___	___

Q 29 HAVE YOU EVER HAD A ADVERSE DRUG REACTION? ____

yes = 1
no = 2
DK = 9
NA = 8

if "yes" what was the drug? _____

Q 30 ARE YOU CURRENTLY USING ANY PRESCRIPTION DRUGS? ____

yes = 1
no = 2
DK = 9
NA = 8

Q 31 PLEASE LIST THE PRESCRIPTION DRUGS YOU ARE CURRENTLY TAKING, THE DOSE AMOUNT OF THE DRUG, HOW LONG YOU HAVE BEEN TAKING THE DRUG AND THE MEDICAL CONDITION FOR WHICH YOU ARE USING THE DRUG:

Name of Drug	Dose	How Long	Medical Condition
1) _____	___	___	_____
2) _____	___	___	_____
3) _____	___	___	_____
4) _____	___	___	_____
5) _____	___	___	_____

I.D. NUMBER ____/____/____

Q 32 DO YOU TAKE ANY OF THE FOLLOWING NON-PRESCRIPTION DRUGS?

YES	NO	DK	NA		(specify)
___	___	___	___	sleep medications	_____
___	___	___	___	iron tablets-tonics	_____
___	___	___	___	antacids	_____
___	___	___	___	vitamins	_____
___	___	___	___	eye drops	_____
___	___	___	___	home remedies	_____
___	___	___	___	diet pills	_____
___	___	___	___	allergy/hay fever	_____

yes = 1
no = 2
DK = 9
NA = 8

Q 33 HAVE YOU BEEN HOSPITALIZED WITHIN THE LAST 5 YEARS FOR ANY MAJOR MEDICAL ILLNESSES OR OPERATIONS? (do not include normal pregnancies)

_____

yes = 1
no = 2
DK = 9

Q 34 I WOULD LIKE TO LIST YOUR HOSPITALIZATIONS BEGINNING WITH THE MOST RECENT HOSPITALIZATION FIRST.

	YEAR	OPERATION OR ILLNESS	NAME OF HOSPITAL	CITY	STATE
1st					
2nd					
3rd					
4th					
5th					

Q 35 WHICH OF THE FOLLOWING ILLNESSES OR MEDICAL PROBLEMS HAVE YOU EVER HAD, AND WHICH HAVE YOU HAD IN THE LAST FIVE YEARS?

	CONDITIONS	EVER YES	EVER NO	5 YEARS YES	5 YEARS NO	
1.	ALLERGIES					
2.	ASTHMA					
3.	DIABETES					
4.	HYPOGLYCEMIA					
5.	EPILEPSY					
6.	KIDNEY TROUBLE					
7.	BLADDER TROUBLE					
8.	CANCER OR TUMOR					
	SPECIFY_____					
9.	STOMACH/DUODENAL ULCER					
10.	RHEUMATISM OR ARTHRITIS					
11.	HIGH BLOOD PRESSURE					
12.	HEART TROUBLE					
13.	STROKE					
14.	THYROID DISEASE					
15.	ECZEMA OR PSORIASIS					
16.	HIVES					
17.	RASHES					
18.	EYE INFECTIONS					
19.	EMPHYSEMA					
20.	BRONCHITIS					
21.	PNEUMONIA					
22.	PANCREATITIS					
23.	NEURALGIA OR NEURITIS					
24.	HEPATITIS					
25.	OTHER LIVER DISEASE					

Yes = 1
Yes, last 5 years = 2
No = 3
DK = 9
NA = 8

Q 36 WE ARE NOW GOING TO LIST SOME GENERAL HEALTH CONDITIONS. PLEASE INDICATE WHICH ONES YOU HAVE EXPERIENCED IN THE LAST FIVE YEARS, AND IF YOU SAW A DOCTOR FOR IT.

	HEALTH CONDITIONS	LAST 5 YEARS YES	LAST 5 YEARS NO	DOCTOR SEEN YES	DOCTOR SEEN NO	
1.	STIFF OR PAINFUL MUSCLES OR JOINTS					
2.	NUMBNESS OR TINGLING IN ARMS OR LEGS					
3.	SHAKING OR UNSTEADINESS, ESPECIALLY OF HANDS AND ARMS					

I.D. NUMBER ____/____/____

4. DIFFICULTY WITH COORDINATION	___	___	___	___	___
5. GENERAL AND PERSISTENT FATIGUE	___	___	___	___	___
6. DIZZINESS, LIGHTHEADED, FAINTING	___	___	___	___	___
7. LOSS OF MEMORY (FOR NAMES OR NUMBERS)	___	___	___	___	___
8. PERSISTENT HEADACHES MORE THAN ONCE A WEEK	___	___	___	___	___
9. BLURRED VISION	___	___	___	___	___
10. PAIN OR ITCHING IN OR AROUND THE EYES	___	___	___	___	___
11. DISCHARGE FROM THE EYES, OR SWELLING OF THE EYELIDS	___	___	___	___	___
12. BURNING OR ITCHING SKIN	___	___	___	___	___
13. PERSISTENT SKIN RASHES OR ERUPTIONS	___	___	___	___	___
14. FREQUENT HEAD COLDS (FOR TWO OR MORE MONTHS IN A ROW)	___	___	___	___	___
15. WHEEZING OR GASPING FOR BREATH	___	___	___	___	___
16. COUGHING SPELLS	___	___	___	___	___
17. COUGHING UP A LOT OF PHLEGM	___	___	___	___	___
18. COUGHING UP BLOOD	___	___	___	___	___
19. CHEST COLDS MORE THAN ONCE A MONTH	___	___	___	___	___

Yes = 1
Yes doctor seen = 2
No = 3
DK = 9
NA = 8

APPENDICES D, E, F, G & H

Appendix D. Means / Percentage Distribution of Selected Characteristics, by County, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	n	Total	County		p-value
			Allegan	Kalamazoo	
N	151		104	47	
Anthropometric measures					
Mean height (inches) (Mean±SD)	151	68.1 ± 4.1	68.1 ± 4.2	68.4 ± 3.9	0.60
Mean weight (lbs) (Mean±SD)	151	177.0 ± 44.6	176.7 ± 46.8	177.4 ± 39.8	0.93
Health habits/exposure					
Smoking status (%):					0.59
Currently smoke	77	51.7	49.0	57.4	
Ever smoked	24	16.1	17.6	12.8	
Never smoked	48	32.2	33.3	29.8	
Drinking status (%)					0.25
Presently drink	103	68.7	66.3	73.9	
Former drinker	19	12.7	11.5	15.2	
Total abstainer	28	18.7	22.1	10.9	
Ever exposed to industrial Chemicals(%)					0.45
Yes	84	55.6	57.7	51.1	
No	67	44.4	42.3	48.9	
Ever exposed to farm Chemicals (%)					0.10
Yes	73	48.3	52.9	38.3	
No	78	51.7	47.1	61.7	
Aware of fish consumption advisories(%)					0.10
Yes	35	26.5	30.5	16.2	
No	97	73.5	69.5	83.8	
Weight change occurred past year (%)					0.10
Yes	64	42.7	47.1	32.6	
No	86	57.3	52.9	67.4	
Changes in weight (%)					*
Increased	37	59.7	64.6	42.9	
Decreased	13	21.0	14.6	42.9	
Both	12	19.4	20.8	14.3	
Self-considered health status (%)					0.06
Excellent	34	22.7	18.4	31.9	
Good	78	52.0	51.5	53.2	
Fair or Poor	38	25.3	30.1	14.9	
Hospitalized in last 5 years(%)					0.27
Yes	39	25.8	29.8	17.0	
No	112	74.2	70.2	83.0	

Percentage may not add to 100 owing to rounding.
Participants in sub-groups may not add to 151 owing to missing values.
P - values of height and weight were determined by Student t - test, other variables by chi-square test.

Appendix E. Percentage Distribution of Self-Reported Medical Problems, by County, Portage Creek-Kalamazoo River Angler Survey, 1993

Medical Problems	Total	County		p-value
		Allegan	Kalamazoo	
N	151	104	47	
Allergies	39.1	49.0	17.0	<0.01
Stomach/duodenal ulcer	15.3	17.5	10.6	0.34
Rheumatism or arthritis	18.0	20.4	12.8	0.36
Hypertension	13.4	16.5	6.5	0.12
Rashes	7.9	10.6	2.1	0.11
Bronchitis	24.7	26.2	21.3	0.55
Numbness or tingling in arms or legs	21.2	20.2	23.4	0.67
Persistent headache (>1/wk)	16.6	21.2	6.4	0.03
Asthma	6.6	6.7	6.4	0.94
Diabetes	3.3	1.9	6.4	0.16
Hypoglycemia	2.6	3.8	0.0	0.31
Epilepsy	0.7	1.0	0.0	1.00
Kidney trouble	7.3	8.7	4.3	0.50
Bladder trouble	6.0	6.8	4.3	0.72
Cancer or tumor	4.0	5.8	0.0	0.18
Heart trouble	6.6	8.7	2.1	0.17
Thyroid disease	4.6	5.8	2.1	0.43
Eczema or psoriasis	4.0	3.8	4.3	1.00
Hives	8.6	10.6	4.3	0.35
Eye infections	6.7	8.7	2.1	0.17
Emphysema	2.0	1.0	4.3	0.22
Pneumonia	12.6	13.5	10.6	0.80
Pancreatitis	0.7	1.0	0.0	1.00
Neuralgia or neuritis	2.0	1.9	2.1	1.00
Hepatitis	6.6	8.7	2.1	0.17
Other liver disease	2.0	2.9	0.0	0.55
Shaking or unsteadiness(esp. hands & arms)	7.9	7.7	8.5	1.00
Difficulty with coordination	2.6	1.9	4.3	0.59
General and persistent fatigue	11.9	12.5	10.6	1.00
Dizziness, lightheaded, fainting	9.9	13.5	2.1	0.04
Loss of memory (for names or numbers)	4.6	4.8	4.3	1.00
Blurred Vision	9.3	12.5	2.1	0.07
Pain or itching in or around the eyes	8.6	11.5	2.1	0.07
Discharge from the eyes, or swelling of the eyelids	4.6	6.7	0.0	0.10
Burning or itching skin	7.9	8.7	6.4	0.75
Persistent skin rashes or eruptions	18.5	20.2	14.9	0.50
Frequent head colds (for 2+ months in a row)	7.9	8.7	6.4	0.75
Wheezing or gasping for breath	7.3	7.7	6.4	1.00
Coughing spells	13.9	16.3	8.5	0.31
Coughing up a lot of phlegm	16.7	21.4	6.4	0.03
Coughing up blood	4.0	4.8	2.1	0.67
Chest colds more than once a month	3.3	4.8	0.0	0.33

Medical problems refer to which participants have ever had.
P - values were determined by Chi - Square test.

Appendix F. Percentage Distribution of Fish Consumption Characteristics in the Past Year, by County, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	n	Total	County		p-value
			Allegan	Kalamazoo	
Species of fish consumed (most often)					NC
Walleye	22	28.2	26.2	35.3	
Bass	14	17.9	11.5	41.2	
Panfish	9	11.5	11.5	11.8	
Catfish	16	20.5	24.6	5.9	
Other	17	21.8	26.2	5.9	
Species of fish consumed (second most)					NC
Walleye	9	12.3	8.8	25.0	
Bass	18	24.7	22.8	31.3	
Pike	8	11.0	10.5	12.5	
Panfish	15	20.5	22.8	12.5	
Other	23	31.5	35.1	18.8	
Always preparation prior to cooking					
Filet	47	69.1	64.8	85.7	0.20
Skin	42	65.6	58.8	92.3	0.03
Trim belly flap	56	86.2	83.0	100.0	0.19
Trim dorsal/lateral fatty area	55	88.7	86.3	100.0	0.33
Scale/remove head/gut	65	91.5	89.8	100.0	0.50
Cooking method (most often)					NC
Broiled	5	6.3	4.8	12.5	
Baked	10	12.7	14.3	6.3	
Pan fried	44	55.7	54.0	62.5	
Deep fried	14	17.7	17.5	18.8	
Other	6	7.6	9.5	0.0	
Cooking method (second most)					NC
Broiled	11	18.3	15.4	37.5	
Baked	16	26.7	25.0	37.5	
Pan fried	11	18.3	19.2	12.5	
Deep fried	6	10.0	9.6	12.5	
Other	16	26.7	30.8	0.0	

Percentage may not add to 100 owing to rounding.
NC: P-value not calculated because of the small number of cases .

Appendix H. Comparison of General Characteristics Between Phase I and Phase II Cohorts, Portage Creek-Kalamazoo River Angler Survey, 1993

Characteristics	Total	Phase I	Phase II	P-value
No of participants	1090	939	151	
Age (%) :				0.01 †
Under 31	46.8	48.1	36.0	
31-45	31.5	30.0	43.9	
Over 45	21.7	21.9	20.2	
Education (%) :				0.24 †
Less than high school	28.5	28.5	28.5	
High school graduation	36.7	37.5	31.8	
Some college	24.5	24.4	25.2	
College graduation	10.3	9.6	14.6	
Ate fish in the past year (%) :				0.16 †
No	54.6	55.7	49.3	
Yes	45.4	44.3	50.7	
Aware of fish consumption advisories (%):				<0.01 †
No	50.4	53.8	26.5	
Yes	49.6	46.2	73.5	
Years of eating KR/PC fish (Mean±SD):	10.70±11.26	10.32±11.43	12.16±10.55	0.20 ‡

†: P-values were determined by chi-square test.
‡: P-value was determined by student t-test.
KR: Kalamazoo River
PC: Portage Creek

APPENDIX I

Extraction Procedures and Analytical Methodologies Used

LABORATORY METHODS - KALAMAZOO RIVER ANGLER SURVEY AND BIOLOGICAL TESTING STUDY

Sample Collection

All human blood specimens submitted to the laboratory for analysis as part of this study were collected, processed and delivered to the laboratory by members of the study team within the Division of Environmental Epidemiology, Michigan Department of Community Health. The specimen logs sheets used in this study were those employed by the division in previous cohort studies. These log sheets unfortunately contained additional information specifically related to packed column gas chromatographic analysis. There were no laboratory data generated on any of the specimens submitted to the laboratory that involved packed column gas chromatography methodology. Any reference to the packed column gas chromatography technique regarding laboratory analysis and subsequent laboratory reported results for this study was incorrect. All PCB and DDE results produced by the laboratory involved high resolution gas chromatographic methodology only.

Venous blood was collected by venipuncture into two 15 mL red top tubes. The specimens were allowed to clot for 15 minutes at room temperature and then centrifuged at 1500 rpm for 10 minutes to separate the serum fraction from packed cells and the fibrous clot. The serum was transferred to hexane-washed glass vials and refrigerated prior to shipment to the laboratory. A unique sample identification number (94 ZP 2 _ _ _was assigned to each specimen collected. These specimens were transported to the laboratory along with the study log sheets. When received at the laboratory, each serum specimens were frozen at -20°C until analyzed.

Whole blood specimens were collected for mercury analysis by cold vapor atomic absorption spectrophotometry. Ten milliliters of venous blood was collected into a venipuncture tube containing heparin as the anticoagulant. Each specimen was assigned a unique sample identification number (94 1ZM _ _ _ _). The sample was immediately mixed following collection to prevent clotting of the specimen. These specimens were refrigerated prior to transport to the laboratory along with the study log sheets.

Extraction and Fractionation

Serum specimens and quality control samples were extracted and fractionated by a modification (unpublished results) of procedures established by the U.S. Environmental Protection Agency (Manual of Analytical Methods for the Analysis of Pesticides in Humans and Environmental Samples, EPA-600/8-80-038, June 1980). Frozen serum specimens and quality control materials were removed from the freezer and allowed to warm to room temperature. Methanol (2.0 mL) was added to 4.0 mL of serum with gentle mixing. The chlorinated pesticides, polybrominated biphenyls (PBB) and polychlorinated biphenyls (PCB) congeners were extracted into 5.0 mL of diethyl ether/hexane (1:1, v/v) with rotary mixing.. The extraction step was repeated twice. The

resulting diethyl ether/hexane extract (15 mL) was concentrated to a final volume of 0.5 mL under nitrogen at 35 °C. The concentrated diethyl ether/hexane extract was then applied to a Florisil® column (7 mm i.d. containing 2.5 g. Florisil® pre-rinsed with 10 mL hexane). Chlorinated pesticides, PBB and PCB congeners were eluted from the Florisil® column with 20 mL of 6% diethyl ether in hexane. The Florisil® column was then eluted with an additional 20 mL of 20% diethyl ether in hexane to generate fraction IV. Fraction IV was concentrated to 0.6 mL under nitrogen at 35 °C, diluted to a final volume of 2.0 mL with iso-octane. The 6% diethyl ether in hexane eluate from the Florisil® column was concentrated to a final volume of 1.0 mL under nitrogen at 35 °C and applied to a Silica Gel60® column (9 mm i.d. containing 5.0 g of Silica Gel60® pre-rinsed with 10 mL hexane). The Silica Gel60® column was then eluted sequentially with 14 mL of hexane to generate fraction I, 20 mL of hexane followed by 8 mL of benzene to generate fraction II, and finally an additional 7 mL of benzene to generate fraction III. The PBB and PCB congeners appear in fraction II while the chlorinated pesticides are present in all four fractions. 1,1-Dichloro-2,2-bis(p-chlorophenyl)ethylene (DDE) elutes in fractions II and III. Figure 1 summarizes the extraction and fractionation process. Fractions I and III were concentrated to 0.6 mL under nitrogen at 35 °C and then diluted to a final volume of 2.0 mL with iso-octane. Fraction II was concentrated to 0.6 mL under nitrogen at 35 °C and then diluted to a final volume of 2.0 mL with iso-octane. In this particular study, only fractions II and III were analyzed by high resolution capillary gas chromatography for PCB congeners and DDE. Two microliters (2 μL) of fraction II was analyzed for PCB congeners by capillary gas chromatography. One microliter (1 μL) of fraction III was analyzed for DDE by capillary gas chromatography.

Gas Chromatography

Capillary gas chromatography of fraction II containing PCB congeners and part of the DDE was performed using a Varian model 3500 gas chromatograph equipped with a Varian model 8100 autosampler, a Varian model 1093/1094 septum-programmable injector with a Y-connector to two high resolution fused silica capillary columns (column 1 was a 60 m x 0.25 mm i.d. DB-5, film thickness 0.25 μm, and column 2 was a 60 m x 0.25 i.d. DB-1701, film thickness 0.25 μm, J & W Scientific), two nickel-63 electron capture detectors and a Varian DS 654 data station. The carrier gas was hydrogen (1.8 mL/min) and the make-up gas was nitrogen (20 mL/min). The injector temperature was 275 °C. The column temperature ranged from an initial temperature of 110 °C to a final temperature of 260 °C. The temperature program was as follows: 110 °C for 1 minute, 110-170 °C at 6 °C/min., 170-230 °C at 1.5 °C/min., 230-260 °C at 3 °C/min., and then held at 260 °C for 16 minutes. The total run time was 77 minutes. The detector temperature was at 320 °C.

Capillary gas chromatography of fraction III containing the remainder of the DDE was performed using a Varian model 3400 gas chromatograph equipped with a Varian model 8200 autosampler, a Varian model 1093/1094 septum-programmable injector onto a high resolution fused silica capillary columns (column 1 was a 60 m x 0.25 mm i.d. DB-5, film thickness, J & W Scientific), a nickel-63 electron capture detector and a Varian Star 4.2 data station. The carrier gas was

hydrogen (1.8 mL/min) and the make-up gas was nitrogen (20 mL/min). The injector temperature was 275 °C. The column temperature ranged from an initial temperature of 200 °C to a final temperature of 260 °C. The temperature program was as follows: 200 °C for 1 minute, then increased from 200 °C to 260 °C at 5 °C/min and then held at 260 °C for 12 minutes. The total run time was 25 minutes. The detector temperature was at 320 °C.

Individual PCB congeners were quantified using an arochlor mixture as a standard according to the method of Mullin *et al* (2,3). The standard mixture was composed of Arochlors 1232, 1248 and 1262 (25:18:18, v/v/v) and PCB congener BZ#169 (4). The total PCB level in the standard was 206.14 μg/L. Table 1 summarizes the PCB composition of the Aroclor mixture used in the calibration of the instruments. The use of the high resolution dual capillary column method allowed separation and quantification of 84 individual PCB congeners and an additional 14 congeners with eluted as 7 dual component peaks. DDE was quantitated using commercially available DDE as the standard (Ultra Scientific, North Kingstown, RI). The total DDE concentration for this standard was 4.0 μg/L.

Table 2 summarizes the 84 individual PCB congeners and 7 coeluting congener pairs along with the limit of quantitation for each PCB congener or PCB congener pair reported in this study. The results for specimen analysis were reported as the actual value quantitated for each individual congener and DDE when it was present at a level greater than its limit of quantitation (LOQ) a congener was reported as a nondetect (ND) when its appearance on the chromatogram was below the limit of quantitation (LOQ). The presence of interferences were noted as an I in the final laboratory report and when a peak corresponding to an individual PCB congener but that failed to meet the relative retention time requirements was noted as an RT in the final laboratory report. Total PCB levels were determined by summing the individual PCB congeners that had a value equal to or greater than the limit of quantitation. Total DDE was reported as the sum of the DDE appearing in fractions II and III when these values were equal to or greater than the limit of quantitation for DDE. The limit of quantitation for DDE was 0.4 parts per billion (ppb, equivalent to 0.4 μg/L).

Analysis of Samples

The Kalamazoo River Angler Survey and Biological Testing Study collected 156 serum specimens for laboratory analysis. There were a total of 156 study samples analyzed by the laboratory for this study. These samples were analyzed in a total of fifteen discrete sets. Set 1 through set 12 consisted of eleven study samples, one sample duplicate randomly selected from the eleven study samples in the set (designated I), a bovine serum blank (matrix blank designated II), a low level bovine serum control containing 10 μg/L Aroclor 1260 (designated AAA) and a high level bovine serum control containing 30 μg/L Aroclor 1260 (designated CCC). Set 13 and set 14 consisted of twelve study samples, one sample duplicate randomly selected from the twelve study samples in the set (designated I), a bovine serum blank (matrix blank designated II), a low level bovine serum control containing 10 μg/L Aroclor 1260 (designated AAA) and a high level bovine serum control containing 30 μg/L Aroclor 1260 (designated CCC). Set fifteen was a

rerun of all samples from set 8. Total mercury was analyzed on whole blood specimens using cold vapor atomic absorption spectrophotometry.

Fraction II for each set was analyzed in the following manner for the presence of DDE and PCB congeners. Initially, an AROS+ standard was injected into the gas chromatograph to activate the instrument columns and detectors. Results from this initial injection were not analyzed. Following this initial injection, the instrument was calibrated using the 3CON1 and the AROS+ standards as calibrators. These standards were used as calibrators for DDE and PCB congener specific quantitation, respectively. The two standards were followed by an iso-octane reagent blank and then by three study samples. DDE and PCB congeners in these study samples were quantitated using this initial instrument calibration. The gas chromatographic system was then recalibrated by running the 3CON1 and AROS+ standards a second time. Four additional study samples were then analyzed and quantitated using the second calibration of the instrument. The instrument calibration process was repeated a third time using 3CON1 and AROS+ standards. An iso-octane reagent blank was run followed by three study samples. These study samples were analyzed and quantitated using the most recent instrument calibration. The instrument was then calibrated a fourth time using the same standards as instrument calibrators. Four more study samples were then analyzed. These study samples were quantitated using the fourth instrument calibration run. The instrument was then calibrated a final time using the 3CON1 and AROS+ standards as instrument calibrators. An iso-octane reagent blank and one additional study sample was then injected into the instrument. This study sample was analyzed and quantitated using the results from this final instrument calibration. At the conclusion of the set, a 3CON3 and AROS+ standards were run on the instrument. The 3CON3 standard was used in cases where a study sample had DDE levels greatly in excess of the 3CON1 standard. The final AROS+ standard was used to recalculate matrix controls and study sample PCB congener results in cases where earlier instrument calibration runs failed due to either sample injection problems or interference caused by the presence of septa peaks.

Fraction III from each set was analyzed for the presence of DDE in the following manner. Initially, a 3CON3 standard was injected into the gas chromatograph to activate the instrument column and detector. Results from this initial injection were not analyzed. Following this initial injection, the instrument was calibrated by a two point calibration procedure using the 3CON1 and 3CON3 standards as calibrators for DDE. The two standards were followed by an iso-octane reagent blank and then by three study samples. DDE present in these study samples was quantitated using this initial instrument calibration. The gas chromatographic system was then recalibrated by running the 3CON1 and 3CON3 standards a second time. Four additional study samples were then analyzed and quantitated using the second calibration of the instrument. The instrument calibration process was repeated a third time using 3CON1 and 3CON3 standards. An iso-octane reagent blank was run followed by three study samples. These study samples were analyzed and DDE was quantitated using the most recent instrument calibration. The instrument was then calibrated a fourth time using the same standards as instrument calibrators. Four more study samples were then analyzed. DDE present in these study samples were quantitated using the fourth instrument calibration run. The instrument was then calibrated a final time using the

3CON1 and 3CON3 standards as instrument calibrators. An iso-octane reagent blank was run followed by one additional study sample. This study sample was analyzed and DDE present was quantitated using the results from the final instrument calibration. At the conclusion of the set, the 3CON3 and 3CON3 standards were run on the instrument. These standards were used for instrument recalibration in cases where earlier instrument calibration runs failed due to either sample injection problems or interference caused by the presence of septa peeks.

Quality Assurance - Quality Control

The laboratory quality assurance program for this study involved verification of specimen identification numbers at the time they were received at the laboratory. Upon acceptance by the laboratory, specimens were assigned a unique laboratory specimen number. The laboratory specimen number along with the study specimen number were included on all work sheets used during the processing and analysis of these samples. The specimen log sheets that accompanied the specimens to the laboratory was a standard form that had been utilized in previous cohort studies. This form included information specific to packed column gas chromatography analysis. This particular laboratory method was not utilized in the analysis the specimens from this study. All laboratory work performed in this study was limited to high resolution capillary gas chromatography and cold vapor atomic absorption spectrophotometry methodology. At the conclusion of the laboratory analysis of the specimens from this study, all specimen results were reviewed to ensure that specimen identifications numbers matched those on study and laboratory specimen logs, all laboratory work sheets and instrument printouts, and all final reports were correct and accurate.

The laboratory quality control program for this study involved the analysis of reagent blanks, matrix blanks, two matrix control materials spiked with Aroclor 1260 at level of 10 and 30 μg/L, respectively, and duplicate serum specimen. The matrix blank, matrix controls and duplicate serum specimen were all treated in the same manner as the serum specimens. Data from these control materials were used to monitor the extraction, fractionation and gas chromatographic analysis. In addition, the laboratory participated in a quarterly interlaboratory proficiency testing program under the Great Lakes Human Health Effects Research Program. This program was administered by the Agency for Toxic Substances and Disease Registry. Table 3 summarizes the laboratory results obtained for the control materials analyzed as a part of this study.

Limit of Quantitation

The limit of detection (LOD) used by the laboratory is defined by the peak reject value for the method. The peak reject value was defined as one half the electron capture detector area counts obtained for the chromatographic peak corresponding to the smallest PCB congener concentration in the standard (AROS+) routinely used to calibrate the instrument. The limit of quantitation (LOQ) was then defined as the highest value obtained from the following three

approaches: (1) two times the level of detection, (2) two and one half times the average level of the compound detected in four or more of a series of ten solvent (instrument) blanks, non detected results are included in this calculation, or (3) three times the average level of the compound detected in two or more of a series of ten method (reagent) blanks or a series of ten matrix blanks. Only the detected amounts are averaged, the non detected values are omitted from this calculation. Table 2 summarizes the limit of quantitation for each of the PCB congeners reported in this study.

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APPENDIX J

KALAMAZOO STUDY (1/24/97) Revised 12/7/99

ID Number	PCB Total	p,p' - DDE	Mercury
0002K1-01	2.9	3.6	ND
0003K0-01	0.4	1.0	ND
0004A1-01	0.9	1.3	ND
0004K0-01	2.8	3.8	2.3
0005K0-01	ND	1.8	ND
0005K0-02	ND	0.7	ND
0005K0-03	0.6	1.0	ND
0006K0-01	1.2	1.8	3.3
0008K2-01	3.5	1.7	5.2
0010K1-01	0.6	1.2	ND
0013A1-01	0.5	0.9	ND
0013A1-02	1.8	10.2	ND
0014A1-01	0.5	1.1	2.0
0014A1-02	0.4	0.7	ND
0015A1-01	3.2	2.5	2.2
0015A1-02	2.5	3.6	3.6
0019K2-01	1.2	1.8	ND
0021A2-01	12.5	26.7	2.6
0021A2-02	3.5	3.6	ND
0021A2-03	7.0	5.5	No Hg sample received
0021A2-04	0.7	2.3	ND
0021A2-05	5.5	2.2	ND
0021K1-01	1.3	2.9	2.5

ID Number	PCB Total	p,p' - DDE	Mercury
0022K1-01	0.3	0.9	ND
0026K1-01	0.8	0.9	ND
0027A2-01	2.5	3.0	ND
0027K-01	8.3	1.9	ND
0028A1-01	37.8	24.3	3.5
0028K1-01	7.3	10.9	ND
0029A1-01	1.3	2.0	2.8
0030A1-01	3.0	5.3	ND
0032A2-01	0.5	ND	ND
0032A2-02	0.9	0.5	ND
0032A2-03	1.0	0.6	ND
0032A2-04	2.1	2.4	ND
0033K1-01	2.3	4.7	ND
0039K1-01	0.8	1.7	ND
0040K2-01	0.2	1.6	ND
0041A1-01	0.6	1.3	ND
0046A2-01	24.1	13.6	5.4
0047A1-01	2.8	3.0	7.3
0047A1-02	4.9	1.3	2.8
0047A1-03	1.6	ND	ND
0047A1-04	0.8	0.5	ND
0047A1-05	1.1	ND	ND
0047A1-06	1.0	1.0	2.6
0051K1-01	5.3	6.9	2.4
0055K1-01	2.7	3.6	2.8

ID Number	PCB Total	p,p' - DDE	Mercury
0055K1-02	6.6	5.9	2.3
0057K1-01	1.1	3.6	ND
0063A1-01	0.9	2.2	ND
0063A1-02	ND	0.7	ND
0063K2-01	4.7	4.3	ND
0066A2-01	1.4	1.5	2.4
0068K2-01	0.6	1.3	ND
0069K2-01	1.4	3.5	ND
0070K2-01	0.2	0.5	ND
0072K2-01	1.5	3.2	ND
0073A1-01	2.9	4.4	ND
0073A1-02	1.4	1.4	ND
0073K2-01	1.5	4.1	ND
0077K1-01	0.5	1.4	ND
0078A2-01	1.4 est.	0.7 est.	ND
0078A2-02	0.9	3.8	ND
0078A2-03	2.5	2.6	ND
0078A2-04	1.1	3.9	ND
0079K1-01	3.5	2.4	4.0
0080A2-01	13.3	3.7	ND
0080A2-02	13.1	3.7	ND
0080K1-01	3.0	2.6	ND
0081K1-01	1.9	2.0	ND
0083K2-01	1.8	5.9	ND
0085K1-01	1.1	1.7	ND

ID Number	PCB Total	p,p' - DDE	Mercury
0086A1-01	TE	TE	ND
0086K1-01	8.8	8.3	5.3
0089K1-01	0.2	1.0	ND
0090K1-01	4.5	2.7	2.5
0092K1-01	0.6	1.8	ND
0095K2-01	0.5	1.9	ND
0096K1-01	0.5	1.3	ND
0097A2-01	1.8	1.4	ND
0097A2-02	2.3	3.1	ND
0097A2-03	0.5	1.0	ND
0097A2-04	1.0	1.8	ND
0097K1-01	9.4 est.	2.8 est.	ND
0104K1-01	0.6	1.5	ND
0106A2-01	2.2	13.5	ND
0108A2-01	0.5	0.9	ND
0108A2-02	0.1	ND	ND
0108A2-03	0.5	0.4	ND
0110A2-01	1.2 est.	1.4 est.	2.5
0116A1-01	1.0	1.3	ND
0116K1-01	1.2	2.5	ND
0117A2-01	1.3	1.9	ND
0122A2-01	1.4	3.2	2.3
0127A2-01	0.6	1.6	ND
0127A2-02	0.7	2.3	ND
0128K1-01	2.5	4.0	ND

ID Number	PCB Total	p,p' - DDE	Mercury
0129K1-01	31.2	5.0	ND
0131A2-01	9.2	ND	ND
0131A2-02	TE	TE	ND
0141K1-01	1.5	1.9	ND
0147A2-01	2.4	1.2	3.7
0152A2-01	ND	0.5	ND
0162A2-01	0.4	0.6	ND
0163A2-01	0.1	0.5	ND
0164A1-01	8.8	ND	ND
0164A2-01	6.9	9.9	ND
0179A2-01	1.9	2.9	ND
0186A1-01	1.7	3.6	3.0
0189A1-01	6.5	2.6	ND
0199A2-01	73.0	6.3	ND
0205A2-01	2.4 est.	6.2 est.	2.5
0210A2-01	0.8	1.6	2.1
0210A2-02	1.9	5.8	ND
0219A2-01	0.2	1.6	ND
0220A1-01	1.3	11.2	ND
0223A2-01	1.8	6.9	9.6
0237A1-01	1.1	4.6	ND
0239A2-01	0.1	1.4	ND
0239K1-01	3.3	6.0	2.0
0245A2-01	0.8	2.1	ND
0252A2-01	2.1	2.8	No Hg sample received

ID Number	PCB Total	p,p' - DDE	Mercury
0324A2-02	TE	TE	ND
0333A2-01	ND	2.1	ND
0347A2-01	9.4	1.5	ND
0351A2-01	ND	ND	ND
0351A2-02	1.5	4.9	ND
0364A2-01	0.3	0.7	ND
0372A2-01	2.0	6.1	ND

Notes:

1. ND = Below limit of detection. The limit of detection is:
   PCB = 0.1 ppb
   DDE = 0.4 ppb
   Hg = 2.0 ppb

2. Technical Error = No laboratory results available.

3. Est. = Estimated values. Sample results reported as estimated values due to insufficient sample quantity for re-analysis.

APPENDIX K-N

Appendix K. Estimates of statistical power with the anticipated available sample size (PCBs)

DISEASE	P1	P2	BETA	POWER(%)
allergy	0.3940	0.3720	-1.6882	4.55
ulcer	0.1540	0.1670	-1.7536	4.01
arthritis	0.0920	0.2690	0.7955	78.52
hypertension	0.1520	0.1320	-1.6093	5.37
rashes	0.1970	0.1790	-1.6794	4.65
bronchitis	0.3180	0.1950	-0.2638	39.74
numbness	0.1670	0.2560	-0.6778	24.83
headache	0.1670	0.1790	-1.7748	3.84
asthma	0.0610	0.0770	-1.5993	5.48
diabetes	0.	0.	0.	0.
hypoglycemia	0.	0.	0.	0.
epilepsy	0.	0.	0.	0.
kidney trouble	0.0610	0.0900	-1.3298	9.18
bladder trouble	0.0450	0.0780	-1.1742	12.10
cancer	0.0150	0.0640	-0.5211	30.15
heart diseases	0.0610	0.0770	-1.5993	5.48
thyroid disease	0.0300	0.0640	-1.0458	14.69
eczema	0.0300	0.0380	-1.7139	4.36
hives	0.1210	0.0640	-0.7559	22.36
eye infections	0.1080	0.0260	0.0476	51.99
emphysema	0.	0.	0.	0.
pneumonia	0.1210	0.1410	-1.6159	5.26
pancreatitis	0.	0.	0.	0.
neuralgia	0.	0.	0.	0.
hepatitis	0.0610	0.0770	-1.5993	5.48
other liver disease	0.0300	0.0130	-1.2101	11.31
shaking	0.0910	0.0770	-1.6474	4.95
difficulty with coordination	0.0300	0.0260	-1.8043	3.00
fatigue	0.0760	0.1670	-0.3283	59.00
dizziness	0.1060	0.0900	-1.6279	5.16
loss of memory	0.0150	0.0770	-0.2516	40.13
blurred vision	0.0760	0.1150	-1.1932	11.70
pain/itching in eyes	0.0610	0.1150	-0.8566	19.49
discharge / eyes	0.0300	0.0640	-1.0458	14.92
burning itching skin	0.0610	0.0900	-1.3298	9.18
skin rashes	0.0450	0.1030	-0.6789	24.83
head cold	0.0450	0.1150	-0.4611	32.28
wheezing for breath	0.0610	0.0900	-1.3298	9.18
coughing spells	0.1360	0.1540	-1.6627	4.85
cough lots of phlegm	0.2000	0.1410	-1.0080	15.62
coughing up blood	0.0610	0.0260	-0.8915	18.67
chest colds	0.0150	0.0380	-1.1616	12.30

Note:

1. Estimate of power is provided to test the null hypothesis P1 (projected true probabilities of success in group with log transformed PCB level less than median) equals to P2 (projected true probabilities of success in group with log transformed PCB level greater than or equal to median), with significance level alpha=0.05 and sample sizes of n1=66 and n2=78 in the two groups.

2. With the sample size available in the study, all power estimates for detecting the differences between PCB level groups were less than 80%, the traditional acceptable lower limit. Only for arthritis did the power to detect a difference between the PCB level groups approach 80%.

Appendix L. Estimates of statistical power with the anticipated available sample size (DDE)

DISEASE	P1	P2	BETA	POWER(%)
allergy	0.4060	0.3730	-1.5541	6.06
ulcer	0.1300	0.1890	-1.0065	15.62
arthritis	0.1470	0.2130	-0.9423	17.36
hypertension	0.1010	0.1620	-0.8933	18.67
rashes	0.2320	0.1200	-0.1877	42.47
bronchitis	0.2650	0.2000	-1.0345	15.15
numbness	0.2030	0.2270	-1.6135	5.37
headache	0.1010	0.2270	0.0689	52.79
asthma	0.0430	0.0800	-1.0576	14.46
diabetes	0.	0.	0.	0.
hypoglycemia	0.0430	0.0130	-0.8428	20.05
epilepsy	0.	0.	0.	0.
kidney trouble	0.0870	0.0530	-1.1491	12.51
bladder trouble	0.0290	0.0950	-0.3464	36.32
cancer	0.0290	0.0530	-1.2555	10.38
heart diseases	0.0580	0.0800	-1.4515	7.35
thyroid disease	0.0140	0.0800	-0.1207	45.22
eczema	0.0290	0.0400	-1.6109	5.37
hives	0.1300	0.0530	-0.3438	36.69
eye infections	0.0880	0.0270	-0.3680	35.57
emphysema	0.	0.	0.	0.
pneumonia	0.0870	0.1470	-0.8577	19.49
pancreatitis	0.	0.	0.	0.
neuralgia	0.	0.	0.	0.
hepatitis	0.0140	0.1070	0.3619	35.94
other liver disease	0.0290	0.0130	-1.2679	10.20
shaking	0.1010	0.0670	-1.2153	11.12
difficulty with coordination	0.0290	0.0270	-1.8846	3.01
fatigue	0.1010	0.1470	-1.1363	12.71
dizziness	0.1010	0.0930	-1.7952	3.59
loss of memory	0.0140	0.0800	-0.1207	45.22
blurred vision	0.1010	0.0930	-1.7952	3.59
pain/itching in eyes	0.0720	0.1070	-1.2391	10.75
discharge / eyes	0.0430	0.0530	-1.6875	4.55
burning itching skin	0.0430	0.1070	-0.5275	29.81
skin rashes	0.0870	0.0670	-1.5027	6.68
head cold	0.0430	0.1200	-0.2960	38.21
wheezing for breath	0.0290	0.1200	0.0974	46.02
coughing spells	0.1160	0.1600	-1.2065	11.31
cough lots of phlegm	0.1470	0.1870	-1.3255	9.34
coughing up blood	0.0430	0.0400	-1.8671	3.07
chest colds	0.0290	0.0400	-1.6109	5.37

Note:

1. Estimate of power is provided to test the null hypothesis P1 (projected true probabilities of success in group with log transformed DDE level less than median) equals to P2 (projected true probabilities of success in group with log transformed DDE level greater than or equal to median), with significance level alpha=0.05 and sample sizes of n1=69 and n2=75 in the two groups.

2. With the sample size available in the study, all power estimates for detecting the differences between DDE level groups were less than 80%, the traditional acceptable lower limit. The highest power to detect a difference between the DDE level groups was 53% for headache.

Appendix M. Estimates of statistical power with the anticipated available sample size (Mercury)

DISEASE	P1	P2	BETA	POWER(%)
allergy	0.2780	0.3570	-2.4266	0.75
ulcer	0.1110	0.0710	-1.6178	5.26
arthritis	0.1110	0.1430	-2.2042	1.39
hypertension	0.	0.	0.	0.
rashes	0.2780	0.0710	-0.5207	30.15
bronchitis	0.2220	0.2860	-2.3564	0.91
numbness	0.1670	0.2860	-2.7305	0.32
headache	0.1110	0.1430	-2.2042	1.39
asthma	0.	0.	0.	0.
diabetes	0.	0.	0.	0.
hypoglycemia	0.0560	0.0710	-2.1056	1.74
epilepsy	0.	0.	0.	0.
kidney trouble	0.	0.	0.	0.
bladder trouble	0.0560	0.0710	-2.1056	1.74
cancer	0.	0.	0.	0.
heart diseases	0.1110	0.1430	-2.2042	1.39
thyroid disease	0.	0.	0.	0.
eczema	0.	0.	0.	0.
hives	0.	0.	0.	0.
eye infections	0.	0.	0.	0.
emphysema	0.	0.	0.	0.
pneumonia	0.0560	0.1430	-2.6903	0.36
pancreatitis	0.	0.	0.	0.
neuralgia	0.	0.	0.	0.
hepatitis	0.	0.	0.	0.
other liver disease	0.0560	0.0710	-2.1056	1.74
shaking	0.0560	0.0710	-2.1056	1.74
difficulty with coordination	0.0560	0.0710	-2.1056	1.74
fatigue	0.1110	0.0710	-1.6178	5.26
dizziness	0.	0.	0.	0.
loss of memory	0.	0.	0.	0.
blurred vision	0.1670	0.2140	-2.2749	1.16
pain/itching in eyes	0.0560	0.2860	-3.6551	0.01
discharge / eyes	0.	0.	0.	0.
burning itching skin	0.1670	0.0710	-1.2103	11.31
skin rashes	0.	0.	0.	0.
head cold	0.0560	0.0710	-2.1056	1.74
wheezing for breath	0.	0.	0.	0.
coughing spells	0.0560	0.2860	-3.6551	0.01
cough lots of phlegm	0.0560	0.0770	-2.1606	1.54
coughing up blood	0.	0.	0.	0.
chest colds	0.	0.	0.	0.

Note:

1. Estimate of power is provided to test the null hypothesis P1 (projected true probabilities of success in group with log transformed MERCURY level less than median) equals to P2 (projected true probabilities of success in group with log transformed MERCURY level greater than or equal to median), with significance level alpha=0.05 and sample sizes of n1=18 and n2=14 in the two groups.

2. With the sample size available in the study, all power estimates for detecting the differences between Mercury level groups were less than 80%, the traditional acceptable lower limit. The highest power to detect a difference between the Mercury level groups was 30% for rashes.

Appendix N. Reproducibility Analysis (Kappa statistic calculation for categorical variables; Pearson's Correlation Coefficient Calculation for Continuous Variable)

Characteristics	Kappa	P-value
Age	0.88	<0.01
Education	0.89	<0.01
Frequency of fishing trips last year	0.48	<0.01
Changes in fishing frequency (between year surveyed and previous years)	0.25	<0.01
Participants eating KR/PC fish	0.58	<0.01
Household members eating KR/PC fish	0.45	<0.01
Participants eating KR/PC turtles	0.50	<0.01
Household members eating KR/PC fish	0.42	<0.01
Give fish to friends	0.25	0.07
Catch and release only	0.61	<0.01
Frequency of fish consumed of participants	0.03	0.79
Frequency of fish consumed of household members	0.04	0.72
Preserve fish	0.10	0.49
Concerned about safety of eating KR/PC fish	0.35	<0.01

KR: Kalamazoo River
PC: Portage Creek

	Correlation Coefficient	P-value
Years of participants eating KR/PC fish	0.65	<0.01

Kappa compares the observed agreement to that expected purely by chance under the null hypothesis of independence. Guidelines for the evaluation of Kappa (k):

$k > 0.75$ denotes *excellent* reproducibility
$0.4 \leq k \leq 0.75$ denotes *good* reproducibility
$0 \leq k \leq 0.4$ denotes *marginal* reproducibility

RESPONSES TO PUBLIC COMMENT

The MDCH released a draft of the Kalamazoo Angler Survey and Biological Testing Study for public comment on October 27, 1998. The initial public comment period lasted until January 15, 1999. MDCH received comments from an engineering firm representing a group of local businesses. Their comments are listed below.

MDCH also received many comments concerning the site from residents of Kalamazoo and Allegan Counties. The comments that addressed the content or format of the draft assessment are listed below. The comments that reflect health concerns regarding the site are addressed in the appropriate section of the study.

Comments from an engineering firm representing a group of local businesses:

1A. The report obtained blood samples from a nonrandom angler population, obtained historical dietary data from questionnaires, and relied on recent fish-consumption information for very slowly accumulated compounds.

Response: A "Limitations" section has been added to the document to address limitations such as these.

2A. They should include the details of characterizing the fish-eater and non-fish-eater groups in the description of the PHASE II objectives, and the influence of potential specification error should be incorporated into the discussion of the results. Characteristics of the people not included in PHASE II should also be included.

Response: A "Limitations" section has been added to the document to address limitations such as these.

3A. The report oversimplifies its own analysis to support a conclusion that PCB levels were found to be higher in the population that consumed Kalamazoo River fish. The complete results of the study found that the consumption of Kalamazoo River fish did NOT contribute significantly to differences found in PCB levels. This more comprehensive and important conclusion is scientifically supported by the study's results but is not made clear.

The study results indicated that age was the primary factor affecting PCB blood levels in this population, not fishing behavior or fish consumption. This point is mentioned in the report, but its implications regarding an explanation other than fish consumption for observed PCB blood level differences are not made clear.

Response: Results from t-test analyses were differentiated from results from regression analyses in the document. The association between age of the angler and serum PCB levels

was also discussed further.

4A. The study does not put the PCB and DDE levels measured in the Kalamazoo River anglers in proper context with general population levels of these compounds. For example, the study fails to point out that the levels found in this angler population are not higher than the general U.S. population. Again, this conclusion is scientifically supported by the study's results and should be made clear.

Additional published literature review is needed to compare the serum PCB levels observed in this study with other studies that evaluated serum PCB levels in humans. This should include published literature concerning PCB levels in the general population and in fish consuming populations. The consistency of body burdens in this population with the general population should be made clear.

Response: *An additional review of literature published after 1996 was completed and results from a relevant study were included in the PHASE II RESULTS section.*

5A. All of the results and the interpretations of the relative exposure calculations need to be either reconsidered following identification of a more rigorous cut point, or the statistical meaning of the median and distributions need to be made clear for the general office.

Response: *Median concentration of PCB and DDE is commonly used for comparison purposes in current published scientific literature. A brief definition of median concentration was added to the document.*

6A. The resolving power of the methods used must be identified and explained. The 1,090 anglers included in the study were only a small percentage of the total fishing population in Kalamazoo and Allegan Counties.

Response: *The purpose of the Kalamazoo River angler survey and biological testing study was to explore relevant hypotheses concerning anglers and their fish-eating behaviors. Because the study was a descriptive study and not a case-control or cohort study, additional statistical analysis and power calculations were not justified.*

7A. Using the mean, SEM and n values provided in Table 21, the calculation of a simple t-test does not yield a significant p-value nor match that provided in the last column of the

table. Were the log-transformed values tested directly in the logarithmic scale, or were the resulting parameters tested after being converted back to a linear scale?

Response: Michigan State University staff conducted the statistical analyses, with assistance from graduate students, and was consistent with analyses completed in published literature.

8A. What basis was the normality of data, or lack of it, evaluated and tested for this data set?

Response: The Shapiro-Wilk test was used to test the hypothesis that the laboratory measurements were normally distributed. Using this test, the normality assumption was determined to be violated and log-transformation was used to normalize the laboratory measurements.

9A. Where do Allegan County anglers who fish only for food, fish?

Response: The study was designed to identify Kalamazoo River fish anglers and look at their fish-eating behaviors as a group. Questions concerning where the anglers fished at different times were not included in the study design.

10A. It is possible that certain anglers that report the use of "catch and release" fishing practices also practice "catch and eat" fishing practices at certain times. What percentage of time did anglers "catch and release" versus "catch and eat"?

Response: This question was beyond the scope of the study and was not included in the study design.

11A. The study did not determine the employment status of the subsistence fishermen.

Response: A main objective of the study was to identify subsistence fishermen. The sample size was not adequate to investigate employment status and questions. Therefore, questions concerning employment status were not included in the study design.

12A. The discussion of the Wisconsin study suggests that a direct comparison can be made between the reported values. However, differences between the study populations and the methods of calculating the "averages" that preclude direct, number-for-number comparisons are present.

Response: The Wisconsin study reported mean PCB and DDE values. This was corrected in the document.

13A. The [Michigan and Wisconsin] medians cannot be directly compared because nondetected samples were excluded from the Michigan data set and, thus, not included in the count to find the median. Conversely, nondetects were recorded in the Wisconsin data set, and thus, apparently were included in the count to find the median.

***Response**: We agree with the reviewer's comment that a direct comparison of medians from different studies where nondetects are either included or excluded respectively should not be done. In this report, the discussion section refers to A Wisconsin Angler Survey (1980) as well as the study conducted to examine frequent Great lakes sport fisherman (1999). The measures of comparison are mean values and can be found in pages 20 and 21 of the final report.*

14A. The report did not include adequate documentation supporting the measurements obtained from blood samples. A reevaluation conducted as part of this review indicated that the analytical quality-assurance process did not adequately document the measurement of the PCB concentration in the blood samples. *(page ii)*

***Response**: We have revised Appendix I to include a detailed description of the analytical procedures used in the measure of PCB and DDE levels in blood samples for this study. Quality-control and quality-assurance procedures as well as the quality control data for this study have also been included in the revision to Appendix I.*

15A. The validity of a sample blood level for PCB is questioned. The sample in question has a PCB level of 73 ppb. Upon review of the original chromatogram and data provided by MDCH, this sample has a very unusual distribution of congener levels and apparent interference. The portion of congeners in not consistent with that found in populations receiving PCB exposure from either occupational contact or fish consumption. *(page 6)*

***Response**: We have reviewed the sample in question. The distribution of PCB congeners in this sample is unusual compared to the other samples. We are confident that these peaks represent PCB congeners. They do not represent the presence of interference. These data suggest that this individual has had a PCB exposure. This exposure to PCB is clearly different from other cohort members. This unusual PCB congener profile is consistent with an exposure to Aroclor 1242, while the other members of this study cohort exhibit a PCB congener profile more closely resembling exposure to Aroclor 1260.*

16A. In addition to not being elevated compared with other measured populations, both the PCB and DDE levels found in most of the samples from this study were close to the reported analytical detection limits. In fact, there is a discrepancy in the reporting of analytical detection limits that needs to be cleared up and the study report needs to provide substantially more detail on the derivation and specifications of detection versus

quantitation limits. In general, the reliability of quantitation and reproducibility of analytical results both drop off dramatically as concentrations approach these analytical limits. The report should acknowledge that these factors are operating in the characterization of values representing the body burden of the "recent-fish-consuming" and "no-recent-fish-consumption" groups.

The report has no direct discussion of the analytical limits and their derivation. There is no appendix containing the information and chromatograms used by the laboratory showing the specific derivation of the analytical limits for this study. In Appendix I, there is a note specifying analytical detection limits. However, the numbers are not in agreement with (and are lower for PCBs and DDE) than those shown on the original data sheets produced by the MDPH Laboratory Analysis Section. *(pages 9 and 10)*

Response: The specimen log sheets that accompanied the specimens to the laboratory were a standard form that had been utilized in previous cohort studies. These log sheets included limits of detection specific to packed-column gas chromatography analysis. This particular laboratory method was not utilized in the analyses of the specimens from this study. These log sheets were prepared by the study coordinator and were used only as a sample identification record. These log sheets provided the laboratory with the sample identification numbers assigned by the study coordinator. Upon arrival at the laboratory, laboratory identification numbers were assigned to the study samples. All subsequent laboratory work was recorded on laboratory-generated forms that contained the correct information regarding limits of detection and limits of quantitation. All laboratory work performed in this study was limited to high-resolution capillary gas chromatography and cold-vapor atomic absorption spectrophotometry methodology. At the conclusion of the laboratory analysis of the specimens from this study, all specimen results were reviewed to ensure that specimen identifications numbers matched those on study and laboratory specimen logs, all laboratory work sheets and instrument printouts, and all final reports were correct and accurate.

Limit of Detection and Limit of Quantitation

The limit of detection (LOD) used by the laboratory is defined by the peak reject value for the method. The peak reject value was defined as one-half the electron capture detector area counts obtained for the chromatographic peak corresponding to the smallest PCB congener concentration in the standard (AROS+) routinely used to calibrate the instrument. The limit of quantitation (LOQ) was then defined as the highest value obtained from the following three approaches: (1) two times the level of detection, (2) two and one-half times the average level of the compound detected in four or more of a series of ten solvent (instrument) blanks, non-detected results are included in this calculation, or (3) three times the average level of the compound detected in two or more of a series of ten method (reagent) blanks or a series of ten matrix blanks. Only the detected amounts are averaged, the non-detected values are omitted from this calculation.

17A. The methods section for biological testing refers to Appendix I for the specifics of

sample extraction and analysis. While Appendix I contains substantial details on the extraction, cleanup, and analysis parameters, several key questions are not addressed. The methods section should indicate that the congener-specific detection is followed by estimation of the total PCB levels through the summation of the congener-specific results. Also, the specific congeners used in deriving this sum should either be specified or included in the cross referenced Appendix.

The methods section on statistical data analysis indicates that measurements below the detectable limit were dropped from consideration. The specific detection limits used and their derivation and justifications should be provided. See related discussion under Primary Comments *(page 17).*

Response: Appendix I has been revised. A detailed description of the analytical methods, limit of detection, limit of quantitation, reporting of results and laboratory quality-assurance/quality-control procedures (QA/QC) used for the measurement of blood specimens for this study has been added to this Appendix.

18A. Issues Related to Appendix J -

Indication of qualified results, analytical limits, and QA/QC procedures *(pages 21-22).*

Appendix J does not indicate that some of the included results were qualified as estimated values; i.e., there was unusual uncertainty about the measurement by the laboratory. The files provided upon request to MDCH did, however, indicate which values were so qualified. Both the use of qualified data and the specific data points with their corresponding qualifier flags should be clearly indicated.

Also, the note included in Appendix J regarding the analytical limits is not clear as to whether the corresponding values are method detection limits, sample quantification limits, or some other type of limit. (See Primary Comments regarding this concern.) The note also appears to indicate that values below the corresponding limit are noted by "ND" a standard abbreviation for nondetectable (ND). However, there are no NDs in the appendix, and it appears that these were omitted and left as blanks. This should be corrected for consistency.

Response: Appendix J has been revised to address these concerns. The analytical limits listed in Appendix J are limits of quantitation (LOQ). The concerns about analytical limits have been addressed in the revision to Appendix I.

19A. Evaluation of MDCH-Supplied QA/QC Documentation (pages 22 - 24)

In addition to the analytical limits, either in this appendix or as a separate appendix, documentation of the QA/QC procedures from the laboratory should be included. This should specify the frequency and methods of calibration of the congener analysis, blank and spiked sample use, accreditation, and recovery/reproducibility estimates. Also, the congeners used for estimating total PCB levels and the process for summing them should be specified.

Response: Quality assurance - quality control procedures used in this study have been described in the revision to Appendix I. Comments related to the frequency of instrument calibration, blank and control samples, and recovery and reproducibility issues have also been addressed in the methods used for this study. The description of the analytical methods used in this study are given in the revised Appendix I. Accreditation remains an open issue. Currently, there are no proficiency testing services available for the analysis of trace environmental contaminants in human blood, urine and tissue. We have been developing proficiency testing samples and standard reference materials containing PCB congeners and chlorinated pesticides as part of a quality assurance/quality control project in support of a research program funded by the Agency for Toxic Substances and Disease Registry. Michigan Department of Community Health and nine other laboratories in the Great Lakes region participate in this quarterly proficiency testing program.

20A. In response to a Freedom of Information Act (FOIA) request, MDCH provided copies of the raw analytical data used to calculate the results presented in Appendix J of the report. Findings based on a review of this data are presented below.

Documentation in the data packages was poor. Although the Laboratory Standard Operating Procedure (SOP) was available for guidance, for the purpose of this review several undocumented assumptions were made. Based on patterns noted between multiple sets of data, it is believed that the following analytical designations are true:

Response: The following summarizes the abbreviations used by the laboratory. These abbreviations appear on the various laboratory work sheets associated with sample analyses for this study.

ISO - iso-octane
I - sample duplicate
II - bovine serum blank
AAA - low-level bovine serum control containing 10 µg/L Aroclor 1260
CCC - high-level bovine serum control containing 30 µg/L Aroclor 1260

21A. Based on these assumptions, it appears that the laboratory analyzed single-point calibration standards, lab control samples, sample duplicates, method blanks, and instrument blanks. No evidence of the addition of spiked surrogate compounds or matrix spike analyses could be found in the data. Without this quality control information, no assessment of sample-specific analytical performance or matrix-specific bias could be performed.

Response: The instrument was calibrated using a single point calibration procedure described in the revised version of Appendix I. There were a total of 156 study samples analyzed by the laboratory for this study. These samples were analyzed in a total of 15 discrete sets. Set 1 through set 12 consisted of eleven study samples, one sample duplicate randomly selected from the eleven study samples in the set (designated I), a bovine serum blank (matrix blank designated II), a low-level bovine serum control containing 10 µg/L Aroclor 1260 (designated AAA) and a high-level bovine serum control containing 30 µg/L Aroclor 1260 (designated CCC). Set 13 and set 14 consisted of 12 study samples, one sample duplicate randomly selected from the 12 study samples in the set (designated I), a bovine serum blank (matrix blank designated II), a low-level bovine serum control containing 10 µg/L Aroclor 1260 (designated AAA) and a high-level bovine serum control containing 30 µg/L Aroclor 1260 (designated CCC). Set fifteen was a rerun of all samples from set 8.

No spiked surrogates were used in this study. Each set of analyses did, however, include a sample matrix blank, a duplicate sample, and two matrix blanks spiked with Aroclor 1260. These matrix blank and matrix controls were analyzed a total of 14 times during the course of this study. The matrix blank did not show the presence of PCB congeners. The low-level control had a mean of 9.9 µg/L Aroclor 1260, with a standard deviation of 1.5 µg/L Aroclor 1260. The high-level control had a mean of 25.3 µg/L Aroclor 1260 with a standard deviation of 3.4 µg/L Aroclor 1260. The characterized mean and standard deviation values for these controls were 9.8 ± 2.6 µg/L Aroclor 1260 and 25.6 ± 3.1 µg/L Aroclor 1260 for the low-level and high-level serum controls, respectively. The above characterized values were used to establish quality control limits for both the low and high-level controls. Control values for this study were considered acceptable if they were within plus-or-minus three times the standard deviation for each control level, respectively. The data for the control measurements performed as a part of this study indicate that all control values were within acceptable limits. The low control for set 9 was outside the acceptable limits. The high control for this set was, however, within acceptable control limits. Under our quality-control rules, it is acceptable to have one of the two controls outside acceptable control limits and still have a valid run. A summary of the serum control results for this study can be found in Appendix I.

22A. No documentation establishing the linearity of the instrument could be found in the analytical data. It is customary (and required under standard EPA methods) to analyze a multiple point calibration curve using standards that cover the expected concentration

range of the samples, including a standard at the quantitation limit of the instrument. The extrapolation of the calibration to concentrations above or below those of the actual calibration standards is not appropriate and may lead to significant quantitative errors. The reported quantitation limits do not appear to be directly related to either the calibration standard or the low-concentration reference standard and range from 16 times lower to 3 times higher than the lowest reference or calibration standard analyzed. The highest reported concentration in the samples is similarly unrelated to the standards, with results reaching as much as five times that in the standards.

Response: In response to these concerns, it is important to clarify the fact that EPA does not have methods for the measurement of PCB congeners in human serum specimens. Their methods are generally limited to water, waste water, sediment and sludge samples. The analysis of human serum and tissue specimens for environmental contaminants has largely been performed on methods developed by the Centers for Disease Control and Prevention.

These issues have been addressed in the revision to Appendix I. The issue of instrument calibration, linearity and the use of spiked surrogate compounds is very complex. At the time this study was performed, the only PCB materials available for use as standards were either individual Arochlors or mixtures containing two or more Arochlors. This has posed serious limitations on the development of calibration standards, calibration procedures, quality control materials as well, as validation of recoveries and linearity.

23A. The reported data was analyzed as 15 discrete data sets.

Response: There were a total of 156 study samples analyzed by the laboratory for this study. These samples were analyzed in a total of 15 discrete sets. Set 1 through set 12 consisted of 11 study samples, one sample duplicate randomly selected from the eleven study samples in the set (designated I), a bovine serum blank (matrix blank designated II), a low-level bovine serum control containing 10 µg/L Aroclor 1260 (designated AAA) and a high-level bovine serum control containing 30 µg/L Aroclor 1260 (designated CCC). Set 13 and set 14 consisted of 12 study samples, one sample duplicate randomly selected from the 12 study samples in the set (designated I), a bovine serum blank (matrix blank designated II), a low-level bovine serum control containing 10 µg/L Aroclor 1260 (designated AAA) and a high-level bovine serum control containing 30 µg/L Aroclor 1260 (designated CCC). Set 15 was a rerun of all samples from set 8.

24A. Deficiencies and irregularities specific to the individual sets are as follows:

Set 1 - Samples were inconsistently labeled throughout. The sample group was labeled 94ZM2001 - 94ZM2015 in the laboratory log. In the final reports and chromatograms, however, the samples were labeled 94ZP0001 - 94ZP0015.

Response: The sample identification logs were developed by the study coordinator, not the

laboratory. The sample identification numbering system for this study was as follows:

94 ZM 2_ _ designated whole blood specimens collected in 1994 for mercury analysis.
94 ZP 0 _ _ designated serum specimens collected in 1994 and submitted to the laboratory for PCB congener specific analysis.

All specimens analyzed by the laboratory for PCB congeners were identified on laboratory work sheets, chromatograms and final reports by the 94 ZP 0 _ _ designation code.

25A Set 2 - The samples were labeled with the 95 ZP prefix, although one notation was found stating that they should be labeled with a 94 ZP prefix. The entire data set was recalculated due to apparent analytical problems. The specific reason for the recalculation was, however, unclear. Handwritten notes on the raw data indicate "problem with B column, not properly picking up all peaks" and first calibration "missing 20 peaks."

Response: *Upon review of our records, these issues are related to set 3, not set 2, as indicated in the review summary. The sample numbering system that appears on the initial laboratory work sheet for this set does indicate 95 ZP 0 _ _ _ when they should have been labeled 94 ZP 0 _ _ _. This labeling error was noted and corrected on all subsequent work sheets, chromatograms and final reports. This labeling error most likely occurred due to the fact that the specimens were collected in 1994 (i.e 94 ZP 0 _ _) but were not analyzed by the laboratory until 1995.*

Set 3 required recalculation of Gas Chromatography(GC) results for PCB congeners. Qualitative review of the chromatograms clearly indicate the presence of PCB congeners in these samples. The problem was related to the quantitative analysis of the GC data. The reason for the recalculation of the data for this set was related to the way in which the data station performs calculations on the raw data. It is not uncommon for there to be a slight increase in the retention times for the PCB congeners during a GC run. When this occurs, the data station does not recognize many of the peaks as being PCB congeners and therefore does not calculate a result for those congeners even though they are present in the sample. When this occurs, retention times are adjusted relative to PCB congener 209. This adjustment of retention times relative to PCB congener 209 then allows the data station to recognize them as PCB congeners and perform the necessary calculations.

26A. Set 5 - All samples and standards in this data set showed poor chromatography, with signs of excessive column bleed and detector overload.

Response: *There is an indication that many of the samples have large, unidentified peaks in the first 13 minutes of the run. However, the PCB congeners do not elute before 15 minutes, at which time the baseline has settled. The only standards with any problem (silicone peaks from the septum in AROS+ and carryover into the following 3CON.1) were not used for*

calibration during this run.

27A Set 7 - This data set was completely rerun because six samples reported no PCBs; a handwritten comment noted that this was 'unusual' and prompted the rerun. The decision to re-analyze samples should be driven by QC data results (for example, surrogate recoveries) and should not be a subjective decision. The fact that the samples were re-analyzed simply because no PCBs were detected would seem to imply that the laboratory wanted and expected to find PCBs, a position which may lead to a conscious or unconscious positive bias to the data. In addition, a large number of hand adjustments were present in this data package, a rationale for these adjustments was not documented and no information was provided to allow the reviewer to recreate the recalculations/changes. One transcription error was found for congener 099; the detected amounts for congeners 170/190 were not entered in the "Dual Column Serum Report," when they were in fact present above the reported detection limit. These values would have increased the PCB level for this sample.

Response: The decision to re-analyze the entire set does not represent a subjective decision. The decision was driven by QC data. One of the six samples in question for this set represents a high serum control (sample 093). This sample as well as the other five samples actually resemble an iso-octane blank and not a typical control or serum specimen. In addition to the fraction II results (PCB containing fraction), the fraction III results (DDE containing fraction) for these samples, one sample being a high serum control, produced highly unusual results. The laboratory log covering the preparation of this set of samples indicates that problems occurred during the preparation of these samples. The decision was therefore made to rerun the entire set, a decision that was in fact made on the basis of objective, not subjective, information, including QC data.

28A. Set 8-15 - These data sets, in combination, contain data for both the initial analyses and re-analyses for one (12-sample) set. The raw data used to calculate the reported results cannot be found in either packet, with the exception of samples 95 ZP 0108, 110, and 111. A notation mentions that these samples were calculated by estimation, subtracting the blank. Both the original analysis and the re-analysis of the blank showed a large number of extraneous peaks, indicating contamination during the extraction process. It is quite likely that this contamination is also present in some or all of the samples in this data set. Based on the noted contamination, all samples in this set should have been re-extracted, not simply re-analyzed. The results for the sample duplicates in this data set were 9.4 and 3.3, respectively, indicating a potential precision problem with this set. One transcription error was found; for sample 120, positive results for congener 153 were not entered in the "Dual Column Serum Report", when they were in fact above the reported detection limit. This value should have increased the PCB concentration for this sample.

Response: Set 15 represents a complete re-analysis of the samples composing set 8 including sample extraction and instrument analysis. There were a few samples from set 8 that contained insufficient serum to allow a re-extraction. For these samples, set 8 samples

were re-analyzed and reported as estimated results. Appendix J has been revised to clarify this concerns. The duplicate sample (laboratory sample numbers 110 and 116) was one of the samples that contained insufficient specimen for re-extraction. All of the data sheets were present in the laboratory records for this set of specimens. The comment concerning a transcription error involving PCB congener 153 for sample number 120 is not valid. There was sufficient specimen remaining to enable a complete re-extraction and re-analysis. In the re-run of this specimen, there were no reportable results obtained for PCB congener 153. The results as reported in revised appendix J for this specimen are accurate.

29A. Set 9 - Samples 95 ZP 0129 and 133 (CCC) showed substantial baseline drift and detector overload; no explanation or correction was mentioned. The calculated concentration for the CCC (or high concentration lab control sample) for this data set was 31.5, while the average concentration for this standard based on the other 14 sets was 25.3. In addition, the calculated concentration for the AAA (low concentration laboratory control sample) for this data set was 14.6, while the average concentration for this standard was 9.9. These high recoveries may indicate a potential high bias to the reported data for all samples in this set.

Response: The baseline drift (Column "B") and detector overload (Column "A") were present in most samples (not Standards) in this set. They are indicative of a problem with sample preparation and interfere with early eluting PCB congeners on the "A" column only. The lack of adequate sample to re-extract necessitated the use of the data generated in this run. The use of the "B" column allowed the rejection of anomalous unconfirmed "Congeners" detected on the "A" side. This problem ends prior to the elution of the PCB congeners present in the controls, so this issue is separate from the next.

The control materials (AAA & CCC) are bovine serum matrix spiked with Aroclor 1260. This technical mixture contains many PCB congeners above, at, and below the individual quantitation limits (Q/L), even at the higher level. It is not surprising to have significant variation in the "PCB Congener Total" based on whether several of the peaks near the Q/L are slightly above (reportable) or slightly below (non-reportable) this limit. The CCC control for this set is within the expected range for this method. However, the AAA control is not within the expected range.

30A. Set 11 - Poor chromatography was observed for sample 95 ZP 0165 and the CCC (high concentration) reference standard. Sample 95 ZP 0165 showed a highly irregular baseline which contained numerous extraneous peaks. A notation was in the packet described this problem as a "series of sharp peaks, possibly silicone, makes DB-5 results questionable." No corrective measures seem to have been taken.

Response: The extraneous peaks appear early in the chromatographic run. These unidentified peaks most likely represent silicone compounds originating from the septum used on the sample vials and inlet to the GC injector. Most of these peaks exit the column prior to PCB congener peaks. In cases where an interference peak in one of the two column chromatograms, only data obtained from the column not showing the presence of the interference was used to report results. In cases where there was an indication that an

interference was present in both column chromatograms, no results for that PCB congener was reported.

31A. Set 12 - Contamination and poor chromatography were noted throughout this data set. The instrument blank showed an irregular baseline and contained numerous extraneous peaks. In addition, the instrument blank analyzed before samples 95 ZP 0173, 174, 175, 176, 177, 178, and 179 showed the presence of contamination.

Response: The extraneous peaks appear early in the chromatographic run. These unidentified peaks most likely represent silicone compounds originating from the septum used on the sample vials and inlet to the GC injector. Most of these peaks exit the column prior to PCB congener peaks. In cases where an interference peak appears in one of the two column chromatograms, only data obtained from the column not showing the presence of the interference was used to report results. In cases where there was an indication that an interference was present in both column chromatograms, no results for that PCB congener were reported.

32A. Set 13 - A series of interfering peaks were present in samples 95 ZP 0186 and 188 (AAA). No explanations were offered and no corrective measures seem to have been taken.

Response: The extraneous peaks appear early in the chromatographic run. These unidentified peaks most likely represent silicone compounds originating from the septum used on the sample vials and inlet to the GC injector. Most of these peaks exit the column prior to PCB congener peaks. In cases where an interference peak appears in one of the two column chromatograms, only data obtained from the column not showing the presence of the interference was used to report results. In cases where there was an indication that an interference was present in both column chromatograms, no results for that PCB congener were reported.

33A. Set 14 - An extremely large number of interference peaks were noted in the first run of the sequence (an Aroclor standard run as an apparent retention time check sample). Numerous interference peaks were also noted in the second run of the sequence (a congener standard run as a check sample). No explanations were offered and no corrective action seems to have been taken.

Response: Interference peaks (most likely originating from sample vial and/or GC injector inlet septum) did appear in the AROS+ check sample. In cases where an interference peak appears in one of the two column chromatograms, only data obtained from the column not showing the presence of the interference was used to report results. In cases where there was an indication that an interference was present in both column chromatograms, no results for that PCB congener were reported. There were no interference peaks noted in the AROS+ standard used in calibration of the instrument. The 3Con1 standard was only used to calibrate the instrument for DDE quantification. There were no interference peaks

associated with the DDE peak for this sample, and therefore the use of this particular calibration run was acceptable. It is not uncommon to observe unidentified peaks originating from sample vial and or GC injector inlet septum material. In most cases these peaks elute from the GC well in advance of the PCB congener peaks. For some of the PCB congeners, there may be cases where an interference is likely present. If this situation is observed on both the DB-5 and DB-1701 columns, no result is reported for that congener.

Comments from residents of Kalamazoo and Allegan Counties:

1B. Self-reported health effects are misleading because low-level exposures to these contaminants may lead to subclinical, chronic health effects.

Response: *A "Limitations" section has been added to the document to address limitations such as these.*

2B. Many study participants did not supply their current age.

Response: *A "Limitations" section has been added to the document to address limitations such as these.*

3B. Blood samples may underestimate true body burdens. What about fat mobilization?

Response: *PCB and DDE bioaccumulate in fat. Therefore, this is an appropriate tissue to estimate body burdens of these chemicals. However, fine-needle aspirates of fatty tissue are more invasive procedures than drawing blood. Therefore, simple blood tests may increase study participation as compared with fine-needle aspiration of fatty tissue. Also, whereas fatty tissue may provide a better actual indication of PCB and DDE body burden, serum levels are adequate to compare two groups of fishermen.*

4B. Was a study conducted concerning PCBs and turtles living in the Kalamazoo River?

Response: *Only fish consumption was considered in this study.*

5B. The study needs to be expanded and should not be considered closed. An extended period is recommended including the development of a committee to ensure timely information updates, meeting announcements, and citizen involvement. Membership in the committee should include women and minorities.

Response: *ATSDR initially funded the study in 1993 for 1 year, with additional funds provided for the second year. ATSDR is currently unable to expand the scope of the study and by what to bring closure to this grant activity.*